Natural Changes In Some Connecticut Woodlands During 30 Years

A. R. Olson

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ABSTRACT

Some of the changes which occurred during 30 years were measured on four tracts of woodland in Connecticut. These woodlands were free of disturbance during the period, and the age of the trees at the beginning of the measurements varied from 25 to 40 years. In many characteristics the four tracts and even the moisture classes within them were surprisingly similar. Thus, these characteristics must apply in general to many woodlands.

The number of trees of all species 0.6 inch d.b.h. or more decreased from 1556 to 736 during the 30 years but the number of trees of a few species actually increased. Basal area averaged 70 sq. ft. per acre in 1927 and 100 in 1957. It was greatest on the moist sites, but the increase during the 30 years was greatest on the dry sites. Oak increased greatly in basal area particularly on the dry sites. While the smaller trees decreased in number, the number of larger ones increased. Those smaller than 5.6 inches d.b.h. decreased from 1460 to 580 per acre while those larger than 11.5 inches d.b.h. increased from 8 to 34 during the 30 years. The reduction in basal area of the minor species coupled with decreased numbers of smaller trees of all species indicates a change from a thicket-like woodland to one of larger trees with less understory.

The proportion of oaks increased greatly in the canopy, particularly on the dry sites. Less than half of the trees of the major species but fully two-thirds of the minor species originated as sprouts.

One-third of the trees of the major species and half of those of the minor species died during the first decade. Mortality decreased during the next two decades. On the other hand, ingrowth of trees growing to 0.5 inch d.b.h. or greater increased during the three decades. Since the mortality and ingrowth per hundred trees were similar in both the numerous species, such as red maple and yellow birch, and the rarer species, the number of red maple or yellow birch trees both attaining 0.5 inch d.b.h. and dying was great.

Few trees grew from subordinate to dominant positions in the undisturbed stands. The larger trees had more defects than the smaller ones, and the trees of sprout origin had no more external defects than those of seedling origin. Tilted or crooked stem and scar or damaged crown were the most frequent defects.

In a separate stand which was burned over in 1932 when it was approximately 35 years old, fire delayed the development of the stand by at least two decades, but did not greatly change the species composition.

Since the shade-tolerant beech and sugar maple are widely distributed and more numerous in 1957 than in 1927, they may become more important components of the stands in the future.

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INTRODUCTION

The vegetation of Connecticut has undergone great changes from the forests which greeted the early colonists. In the 20th century much of the change has been the natural and unmanaged regrowth of trees on abandoned farms and clear-cut forests. This Bulletin tells how the trees in four typical Connecticut woodlands have changed in 30 recent years without the intervention of man, and in a fifth where the changes were interrupted by fire.

The original forest which covered most of the land had probably been disturbed little by the original inhabitants, the Indians, and consisted of communities of stately trees which had evolved through the ages. To the early settlers these forests provided timber for building and firewood for warming their shelters. Timber could also be traded.

The need for food required, too, that trees be cleared to provide land suitable for crops and pasture. Deforestation continued until the mid-1800's when two-thirds of the land had been cleared. As the frontiers of the country expanded, some farmers began to migrate to the westward, while others settled in cities of rapidly developing industry in Connecticut. Also as gasoline replaced horses and oxen, land was no longer needed to sustain these animals. Thus farm land was abandoned, and a succession of native plant species invaded the land. This continued until today two-thirds of the land is clad by trees. Half of this woodland is old field in varied stages of succession of species that depend on time of abandonment.

The other half of the present-day woodlands has always been tree-clad, but has been cut over repeatedly for lumber, firewood, and charcoal. Since coal and oil have replaced wood as fuel, and trees large enough for lumber have been depleted, cutting has slowed. In the past, fires periodically burned over large areas of this residual forest. Even though fires have been greatly restricted through better control, past damage has affected the present composition by decreasing the abundance of more susceptible species. Early in the 20th century, chestnut blight eliminated that great tree and left the vast gaps in the canopy. Hurricane, drought, ice and snow also have affected the evolving forests.

Since most clearing ceased, since much farm land was abandoned, and since chestnut was essentially eradicated between 1900 and 1927, many seedlings and sprouts were established or released 40 to 60 years ago. Thus the trees on many acres are just now reaching profitable sawtimber size. Concurrently, we are concerned with more than a simple scheme based upon the clear goal of lumber. We seek amenity and recreation in the suburban forest, with due regard for conservation. Resurgence of the forest requires decisions concerning our use of it, and we need the records of natural change in the woodland that Forester Emeritus H. W. Hicock began keeping a generation ago. These will indicate the direction of natural metamorphosis in many unmanaged woodlands. These will give clues to the management that will be easier because it complements natural tendencies, or more difficult because it opposes natural tendencies, and to what will happen if man leaves the woods untended.

DESCRIPTION OF THE TRACTS

This study was initiated in 1926 on an 80-acre tract called Turkey Hill in the Cockaponsett State Forest in south central Connecticut. In 1927 study began of the 50-acre Cox tract, the 40-acre Reeves tract, and the 40-acre Cabin tract, all in the Mountain Block of the Meshomasic State Forest in central Connecticut. These were selected as representative of forests and sites in the central hardwood region that covers most of Connecticut. Further, the stands were reasonably uniform in age and density and several important soil types were well represented.

All tracts are near the western end of the Eastern Highlands of Connecticut, a region of metamorphic rocks and glaciated soils. The topography is gently rolling to rugged with considerable rock outcrop. Elevation ranges from 400 to 800 feet. Of the four tracts, Turkey Hill is most exposed to strong southeasterly gales such as those that occurred during the 1938 hurricane.

The forest cover was the mixed hardwood type typical of much of the woodlands in Connecticut, with 36 species represented on the transects. In 1927 the trees varied from 25 to 40 years in age with occasional older trees. Observation and inquiry indicated that a portion of each tract had been cleared in the past, but the exact boundaries of clearings could not be ascertained. Chestnut was present on all tracts as evidenced by continued sprouting. Since the study was started in 1926 and 1927 disturbance by man has been slight, and most disturbed areas have been eliminated from this study; a burned area on Turkey Hill is analyzed in a separate chapter.

PREVIOUS STUDIES ON THE TRACTS

Initially Hicock et al. (1931) laid out the tracts to study the relation between soil type and vegetation. Correlation of the different tree species with specific soil types was largely unsuccessful, but after classifying the soils into four broad groups on the basis of moisture conditions, some correlation became evident.

Lunt and Baltz (1944) studied the relation between the basal area of the different species and soil depth, soil moisture, humus type, and thickness, slope, and aspect. Soil moisture and soil depth were the site characteristics most significantly related to basal area.

Collins (1962) studied the composition, structure, growth, changes, and the causes of change occurring on Cox tract from 1927 to 1957. In this preliminary report on Cox tract alone, the studies made were similar to those now reported for all four tracts. In the present report more emphasis has been placed on the effect of soil moisture on the woodlands. The broader sample of four tracts permits several tests of generality of results and, hence. broader application of conclusions.

METHODS

All tracts were laid out as rectangles with the long axis east-west. The dimensions were: Turkey Hill, 20 x 40 chains; Cox, 14 x 36 chains; Reeves, 10 x 40 chains; and Cabin, 20 x 20 chains. A chain is 66 feet and an acre is 10 square chains. Transect lines were laid out south to north at 5-chain intervals on Turkey Hill and at 4-chain intervals on the other tracts. Characteristics of site such as soil type, soil depth, soil drainage or moisture, stoniness, humus type, slope, and aspect were determined and mapped along the transect lines. Along a strip 0.25 chain wide centered on the transect lines, each tree 0.6 inch d.b.h. (diameter breast high) or greater was plotted on a map, identified, and described.

Initially, description included d.b.h. crown class (on all tracts except Turkey Hill), and whether or not the tree was a member of a sprout group. Witch hazel was not recorded on Turkey Hill in 1927, but it was in 1937 and 1957. Crown class is defined in *Forest Terminology* (Soc. Amer. Foresters, 1950).

In 1937 the same information was recorded for stems tallied in 1927. Deaths and new trees (ingrowth) 0.6 inch d.b.h. or larger were noted. Crown class was recorded on Turkey Hill in 1937.

In 1957 the same information was again recorded, but the minimum d.b.h. was decreased to 0.5 inch. In addition, the height of all dominant trees and every tenth tree other than dominants was measured with an Abney level. Trees for which height was measured and any companion sprout were also examined for defects. The defects were in form and symmetry and those caused by injury to the stem or crown and do not include internal defects such as heartrot.

In 1932 a resurvey of the Turkey Hill tract was made following a fire which burned approximately 40 per cent of the area. In addition to the same information gathered in 1927, the extent of the fire on the transect lines, deaths, new recruits, and crown class were recorded. The information from the burned part of Turkey Hill appears in a separate section in this report.

After the 1957 resurvey, the information from all surveys was transferred to punch cards and summarized by machine.

SITE CHARACTERISTICS

Although soil type, depth of soil, internal soil drainage, stoniness, humus type, and aspect were determined along the transects, only internal soil drainage is used here in relating tree or stand characteristics to site because past studies indicated it to be the more important one.

Soil drainage classes were classified according to the Soil Survey Manual (1951). In addition to the 7 classes given in the manual, one was added for the muck site on Turkey Hill. Because the area sampled in some drainage classes was small the classes were combined into four groups as follows: (A) 7, muck; (B) moist sites which included 0, the very poorly drained, and 1, the poorly drained; (C) medium moist sites which included 2, the imperfectly or somewhat poorly drained (only .06 acre), 3, the moderately well drained, and 4, the well drained; and (D) dry sites which included 5, the somewhat excessively drained, and 6, the excessively drained soils. The area sampled in each drainage class and in each combined group is shown in Table 1.

RESULTS

The metamorphosis of the tree population during 30 years is summarized in Figures 1 and 2. Figure 1 depicts the proportion of the different species in basal area, the relative importance of each in the canopy, and the changes that have occurred during the 30 years. Strikingly, this Figure illustrates the increasing predominance of oaks, particularly on the drier sites, and the disappearance of the pioneers that is imperceptible in a day but clear in a generation. Figure 2 depicts the relative abundance of the different species and the influences of mortality and ingrowth during 30 years.

The metamorphosis is examined in detail on the following pages for these characteristics: 1. Number of trees; 2. basal area; 3. distribution of diameter; 4. height in 1957; 5. species in the canopy; 6. proportion of trees growing from subordinate to dominant positions; 7. proportion of single stems to known sprouts; 8. mortality; 9. ingrowth; and 10. defects.

All characteristics except diameter and defect were examined in relation

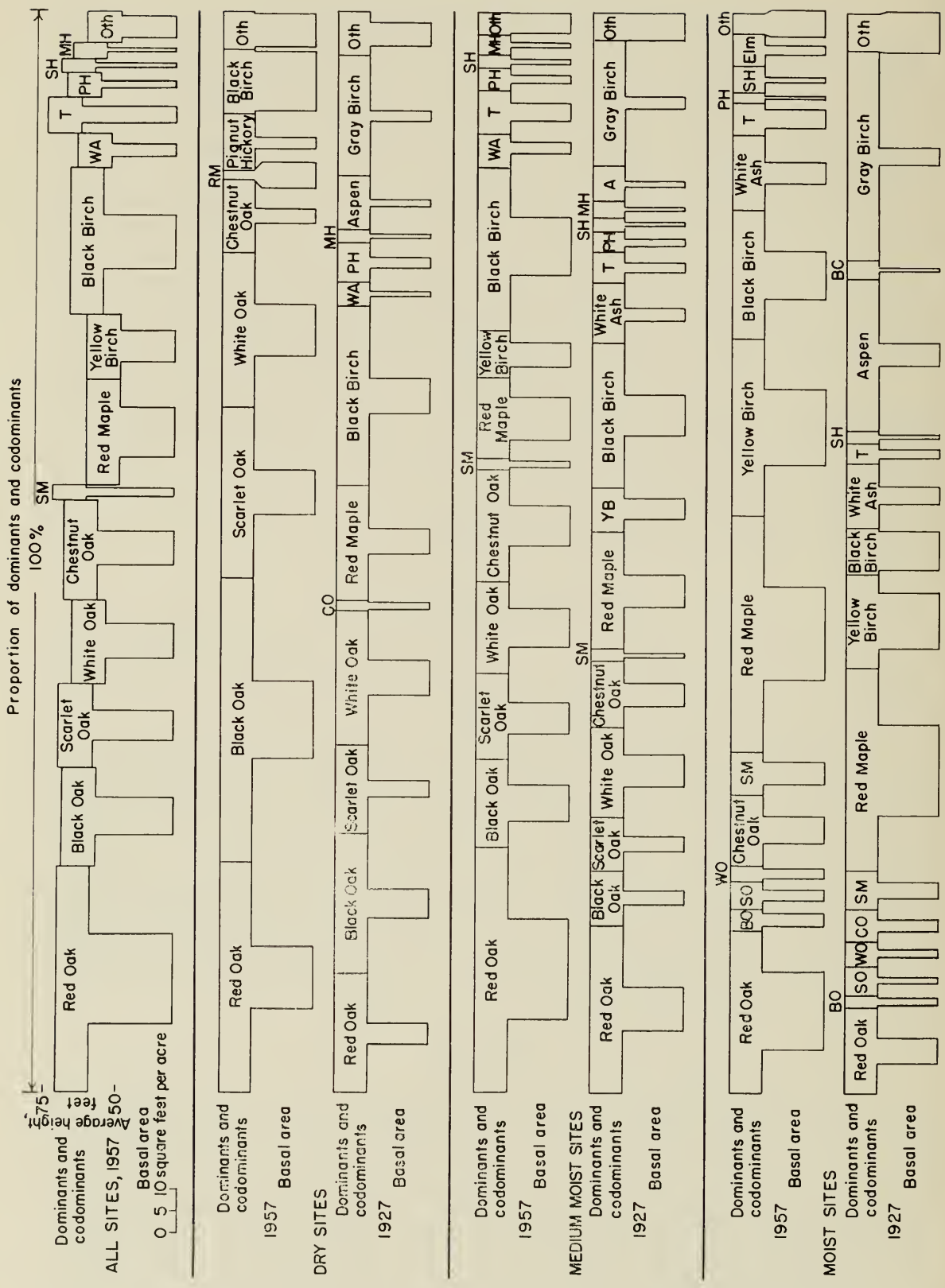

Figure 1. Tree shaped histograms showing changes in the proportion of dominant and codominant trees in the canopy and changes in basal area during 30 years; also average height of trees in 1957.

In the figure, A indicates Aspen; BC, Black Cherry; BO, Black Oak; CO, Chestnut Oak; MH, Mockernut Hickory; Oth, Others; PH, Pignut Hickory; RM, Red Maple; SH, Shagbark Hickory; SM, Sugar Maple; SO, Scarlet Oak; T, Tuliptree; WA, White Ash; WO, White Oak; and YB, Yellow Birch.

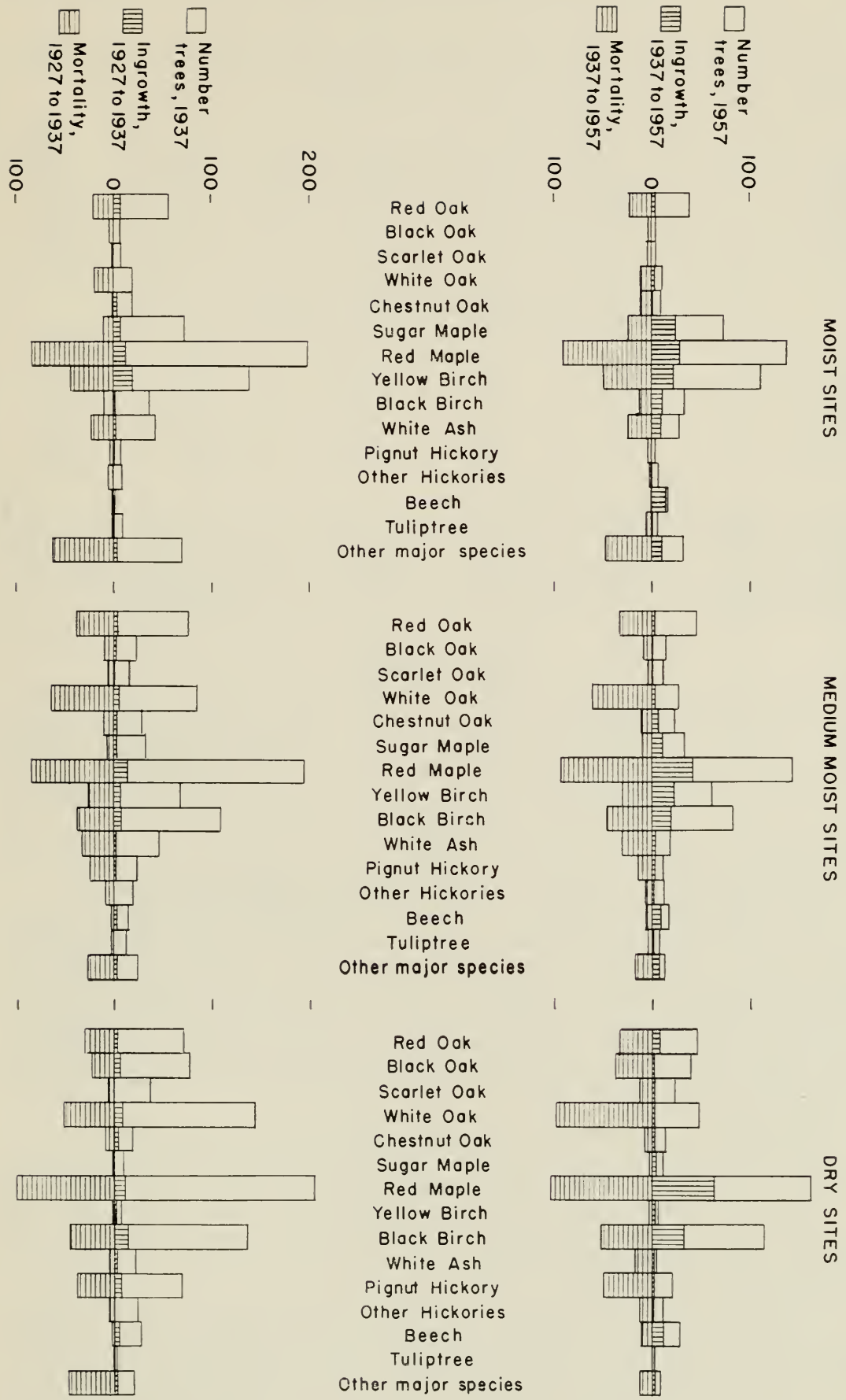

Figure 2. Total number of trees, mortality, and ingrowth for the major species, all in number of trees per acre.

Table 1. Sample area (acres) of soil drainage classes, undisturbed sites only

TRACT	A	B		C			D		
	7	0	1	2	3	4	5	6	All classes
Turkey Hill	.16	.44	.14	.06	.20	1.31	.06	.03	2.40
Cox	....	.03	.48	....	1.09	.97	.60	....	3.17
Reeves	....	.11	.22	....	.42	1.00	.73	...	2.48
Cabin	....	.15	.18	....	.76	1.15	....	....	2.24
Combined	.16	1.75			6.96		1.42		10.29

COMBINED DRAINAGE CLASSES

	Muck	Moist sites	Medium moist sites	Dry sites	All sites
Turkey Hill	.16	.58	1.57	.09	2.40
Cox	....	.51	2.06	.60	3.17
Reeves	....	.33	1.42	.73	2.48
Cabin	....	.33	1.91	....	2.24
All tracts	.16	1.75	6.96	1.42	10.29

to soil moisture. Separate tabulations were made for the major and minor species (Table 3). Only a portion of all the statistics accumulated can be printed in this Bulletin, the ampler tables can be found in an unpublished manuscript with the same title as this Bulletin; this book is in the Station Library.

Number of Trees

In 1927 when the stands were quite young, there was an average of 1073 trees of the 29 major species and 483 of the 7 minor species per acre on the four tracts. By 1957 when the trees were larger and older the number of trees of the major species had declined to 516 per acre and the number of the minor species trees to 220. The number of trees of the major species decreased by 311 per acre during the first decade and by 246 per acre during the next two decades. The numbers of the minor species decreased by 211 and 52 per acre during corresponding periods (Table 2). The species are classified in Table 3.

The total number of trees of the major species differed significantly among tracts in 1927 but not in 1957. There was a maximum difference between tracts of 67 per cent in 1927, but only 14 per cent in 1957. Similarly the maximum difference between tracts in number of trees of the minor species decreased from 207 per cent in 1927 to 74 per cent in 1957. The abundance of the pioneer species, gray birch, aspen, and black cherry on Cox in 1927 indicates that much of the stand there was younger than the other tracts and this accounts for the greater number of trees.

Compared to the moist sites of the four tracts in 1927, there were 20 per cent more trees of the major species on the medium moist and 27 per cent more on the dry sites, but in 1957 the differences were only 2 and 6 per cent.

Six species: red maple, red oak, white oak, yellow birch, black birch, and white ash comprised about three-fourths of the total number of trees in both 1927 and 1957. Red maple comprised about one-fourth of the major species throughout the 30 years.

During the 30 years some species increased in per cent of the total number even though their absolute numbers decreased. Significant changes were increases in sugar maple, red maple, yellow and black birch, and beech and decreases in white oak, white ash, pignut hickory, black cherry, and aspen. The other 19 major species increased or decreased little in per cent of the total from 1927 to 1957.

Table 2. Number of trees on undisturbed sites

	Site	Turkey Hill	Cox	Reeves	Cabin	All tracts
		Major species (trees/acre)				
1927	Moist	688	1425	852	636	924
	Medium moist	864	1270	1216	1046	1107
	Dry	599	1232	1202	.....	1175
	All sites	774	1292	1164	985	1073
1937	Moist	624	897	594	600	693
	Medium moist	674	764	869	776	770
	Dry	495	858	909	.....	860
	All sites	631	805	845	750	762
1957	Moist	553	546	398	471	506
	Medium moist	566	517	495	491	516
	Dry	620	524	535	.....	535
	All sites	556	522	494	489	516
		Minor species (trees/acre)				
1927	Moist	314	1172	509	248	589
	Medium moist	579	871	273	266	516
	Dry	264	282	207	.....	241
	All sites	467	805	285	262	483
1937	Moist	189	568	319	236	333
	Medium moist	375	432	166	175	293
	Dry	158	148	94	.....	120
	All sites	296	399	165	184	272
1957	Moist	313	205	384	347	301
	Medium moist	351	200	162	206	228
	Dry	74	78	118	.....	99
	All sites	312	179	179	226	220

Of the minor species gray birch, blue beech, and witch-hazel were most abundant in 1927 and blue beech, witch-hazel, dogwood, and chestnut in 1957. Only witch-hazel, dogwood, and chestnut increased significantly in per cent during the 30 years.

Some of the major species differed greatly in representation on the four tracts. Chestnut oak was remarkably abundant on Turkey Hill and Cabin, yellow birch on Turkey Hill, and black birch on Reeves and Cabin. White ash was notably scarce on Cabin. Some less abundant species were entirely absent from some tracts. All minor species were represented on all tracts. Gray birch and blue beech were remarkably abundant on Cox, witch-hazel on Cabin, and dogwood on Turkey Hill. Available seed is undoubtedly the most important factor in local abundance of species, but ability to sprout and tolerance of shade are also important in maintaining some species in the stands.

On muck, found only in Turkey Hill, approximately two-thirds of the trees were red maple, and others in order of decreasing abundance were white ash, elm, yellow birch, black ash, tupelo, red oak, and black birch. Numbers of all except elm and tupelo increased from 1927 to 1957. The hurricane of 1938 felled a number of the larger trees here, and from 1937 to 1947, red maple, particularly sprouts, grew in rapidly. Blue beech, witch-hazel, and shadbush were the only minor species present and these were few, 31 trees per acre in 1927 and 74 in 1957.

Of the major species on the four tracts, red maple was the most abundant

Table 3. Number of trees of major or minor species (per cent of total), all tracts

	Muck		Moist sites		Medium moist sites		Dry sites		All sites	
	1927	1957	1927	1957	1927	1957	1927	1957	1927	1957
Major species										
Sugar Maple	0	0	8.1	14.3	3.3	6.4	1.0	2.0	3.7	7.0
Red Maple	68.6	63.4	29.2	26.9	24.0	27.5	25.0	30.3	25.1	28.3
Red Oak	0	1.4	7.6	7.5	9.9	8.7	8.3	8.4	9.3	8.2
Black Oak	0	0	1.1	.7	2.9	2.8	8.0	7.4	3.4	3.1
Scarlet Oak	0	0	.9	.8	1.9	2.3	3.5	4.3	2.0	2.3
White Oak	0	0	4.2	2.0	13.0	5.1	16.1	8.8	12.1	5.1
Chestnut Oak	0	0	1.8	1.7	3.3	4.5	2.0	2.5	2.8	3.7
Yellow Birch	2.0	5.6	17.6	21.7	8.0	11.7	.7	1.0	8.3	11.8
Black Birch	0	1.4	4.8	6.6	12.7	15.7	14.3	21.3	11.7	14.8
White Birch	0	0	0	0	.1	.2	0	0	.1	.1
White Ash	11.8	18.3	6.8	5.5	7.0	3.6	2.0	.9	6.2	3.8
Black Ash	2.0	2.8	.2	.1	.1	0	0	0	.1	.1
Pignut Hickory	0	0	1.2	.7	4.2	2.1	8.6	3.8	4.4	2.1
Shagbark Hickory	0	0	.9	1.1	1.0	1.0	.7	.5	.9	.9
Mockernut Hickory	0	0	.4	0	1.3	1.3	1.9	1.6	1.3	1.1
Bitternut Hickory	0	0	.2	0	.2	.1	0	0	.2	<.1
Tuliptree	0	0	1.1	1.0	1.3	1.3	.2	.4	1.1	1.1
Beech	0	0	.2	3.2	1.4	3.1	2.2	5.3	1.3	3.4
Black Cherry	0	0	3.3	.1	.5	0	.9	0	1.0	<.1
Basswood	0	0	.4	.2	.3	.1	0	0	.3	.1
Elm	11.8	7.0	2.4	1.7	.2	.1	.1	0	.5	.4
Butternut	0	0	.4	0	.4	0	.7	0	.4	.0
Tupelo	3.9	0	2.1	2.3	1.0	.6	.3	.3	.7	.8
Black Locust	0	0	0	0	0	0	.2	.1	<.1	<.1
Sassafras	0	0	1.2	1.7	1.3	1.3	1.6	1.0	1.3	1.3
White Pine	0	0	0	0	<.1	.2	0	0	<.1	.1
Hemlock	0	0	.1	.1	<.1	.1	0	0	<.1	.1
Red Cedar	0	0	0	0	.4	<.1	.2	0	.3	<.1
Aspen	0	0	3.8	0	.7	.1	1.7	0	1.3	.1
No. trees/acre	313.9	437.0	923.6	506.0	1107.5	516.4	1175.3	535.2	1072.9	516.0

	Muck		Moist sites		Medium moist sites		Dry sites		All sites	
	1927	1957	1927	1957	1927	1957	1927	1957	1927	1957
Minor species										
Gray Birch	0	0	15.7	.4	13.0	.3	27.1	0	14.6	.3
Blue Beech	60.1	41.7	45.9	29.7	38.4	21.6	20.1	14.2	38.7	23.2
Witch-Hazel	20.1	49.9	25.8	51.0	25.5	37.0	15.2	16.3	24.9	39.1
Dogwood	0	0	2.6	4.7	10.0	16.3	9.0	8.5	8.4	13.1
Ironwood	0	0	5.2	9.3	7.9	5.5	6.4	13.4	7.2	6.8
Hophornbeam	20.1	8.4	4.3	1.1	3.0	.9	9.9	2.8	3.8	1.1
Chestnut	0	0	.5	3.8	2.2	18.3	12.3	44.6	2.5	16.5
No. trees/acre	30.8	73.9	588.6	301.4	515.8	228.2	241.5	99.3	482.7	220.5

and provided about an equal percentage of the total on moist, medium moist, and dry sites (Table 3). Some other major species in order of decreasing abundance were:

1. Moist sites: yellow birch, sugar maple, white ash, tupelo, elm, aspen, black cherry, and sassafras.
2. Medium moist sites: red oak, chestnut oak, and tuliptree.
3. Dry sites: black birch, white oak, black oak, pignut hickory, scarlet oak, beech, and mockernut hickory.

Although these species were most abundant on the sites indicated, some were also well represented on other sites (Table 3).

The significant changes in per cent of the total number of trees from 1927 to 1957 were:

1. Moist sites: increases in sugar maple, yellow birch, and beech and decreases in white oak, black cherry, and aspen.
2. Medium moist sites: increases in sugar and red maple, chestnut oak, yellow and black birch, and beech and decreases in white oak, white ash, pignut hickory, black cherry, and aspen.
3. Dry sites: increases in red maple, black birch, and beech and decreases in white oak, white ash, pignut hickory, black cherry, butternut, and aspen.

There were many significant changes in per cent of total for the minor species. On the moist sites witch-hazel and chestnut increased while gray birch, blue beech, and shadbush decreased. On the medium moist sites there were increases in witch-hazel, dogwood, and chestnut and decreases in gray birch, blue beech, hophornbeam, and shadbush. On the dry sites there were increases in hophornbeam and chestnut and decreases in gray birch, and shadbush.

Thus, during 30 years of stand development the number of trees of both the major and minor tree species was reduced by one-half.

Basal Area

As a measure of density of stocking and growth, basal area was calculated in square feet per acre from diameter breast high, outside bark, for all trees.

On the combined four tracts basal area averaged 70 square feet per acre in 1927, 88 in 1937, and 100 in 1957 (Table 4). It was significantly greater on the moist than on the dry sites.

Although basal area was greater on the moist than on the medium moist or dry sites during the 30 years, the increase per decade was greater on the medium moist and greatest on the dry sites (Figure 3). This is also true when considering only the major species and excluding areas disturbed by hurricane. Thus although in 1927 the basal area of the major species was 17 and 38 per cent less on the medium moist and dry sites than the 77 sq. ft. per acre on the moist sites, by 1957, it was only 3 and 16 per cent less than the 102 sq. ft./acre on the moist sites.

The seven minor species contributed 10 per cent of the total basal area in 1927, 6 per cent in 1937 and only 3 per cent in 1957. Decreases occurred on all soil moisture classes of all tracts except Turkey Hill where growth resurged, particularly on the moist sites after the 1938 hurricane. The minor species comprised 17 per cent of the average basal area in 1927 on Cox, much of it on a part of the tract which had formerly been cleared. The reduction in basal area of minor species coupled with decreased numbers of trees indicates a change from a thickt-like woodland to one of larger trees with little understory.

Discrepancies noted in basal area are explained as follows. The 1938 hurricane felled trees on the moist and medium moist sites on Turkey Hill and on

Table 4. Basal area on undisturbed sites, all tracts

Tract	Moist sites			Medium moist sites			Dry sites			All sites		
	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957
	Basal area, sq. ft./acre — all species											
Turkey Hill[a]	93	97	100	69	87	97	45	47	62	72	85	93
Cox[b]	89	104	102	74	91	100	48	71	82	72	89	97
Reeves	83	99	118	69	90	97	56	76	94	67	87	99
Cabin	71	90	111	69	92	110	....	....	....	70	92	110
All tracts	86	98	106	71	90	102	52	72	87	70	88	100
	Minor species as per cent of total basal area of all species											
Turkey Hill	5	4	5	11	8	5	6	6	2	9	7	5
Cox	22	15	5	17	11	3	11	6	1	17	11	3
Reeves	7	4	3	4	2	1	6	2	1	5	3	1
Cabin	7	4	4	5	3	1	....	....	....	5	3	1
All tracts	11	7	4	10	6	3	8	4	1	10	6	3
	Increase in basal area, (sq. ft./acre per decade), major species											
	1927 to 1937	1937 to 1957		1927 to 1937	1937 to 1957		1927 to 1937	1937 to 1957		1927 to 1937	1937 to 1957	
Turkey Hill	5	1.5		18	6		2	8		14	4.5	
Cox	20	4		19	8		23	8		21	7	
Reeves	18	10		22	4		21	10		21	6.5	
Cabin	21	10		24	9.5		....	....		23	9.5	
All tracts	14	5.5		20	7.5		21	8.5		19	7	

[a] Data for the 1/6 acre of the very wet muck site represented on Turkey Hill only are not listed separately in this table but are included in the totals for all sites. Basal area was low, 45 sq. ft./acre in 1927, 53 in 1937, and 47 in 1957. The decrease from 1937 to 1957 resulted from the 1938 hurricane which caused a decrease from 45 to 31 sq. ft./acre for red maple during this period. Basal areas of the eight other species present in 1957 were: white ash, 6; elm, 5; black ash, 2; yellow birch, 1; and red oak, blue beech, shadbush, and witch-hazel each with a basal area less than 1.

[b] In Connecticut Station Bulletin 653, on pages 17 and 23 the basal area for Cox should read 59 sq. ft./per acre in 1927 and 93 in 1957.

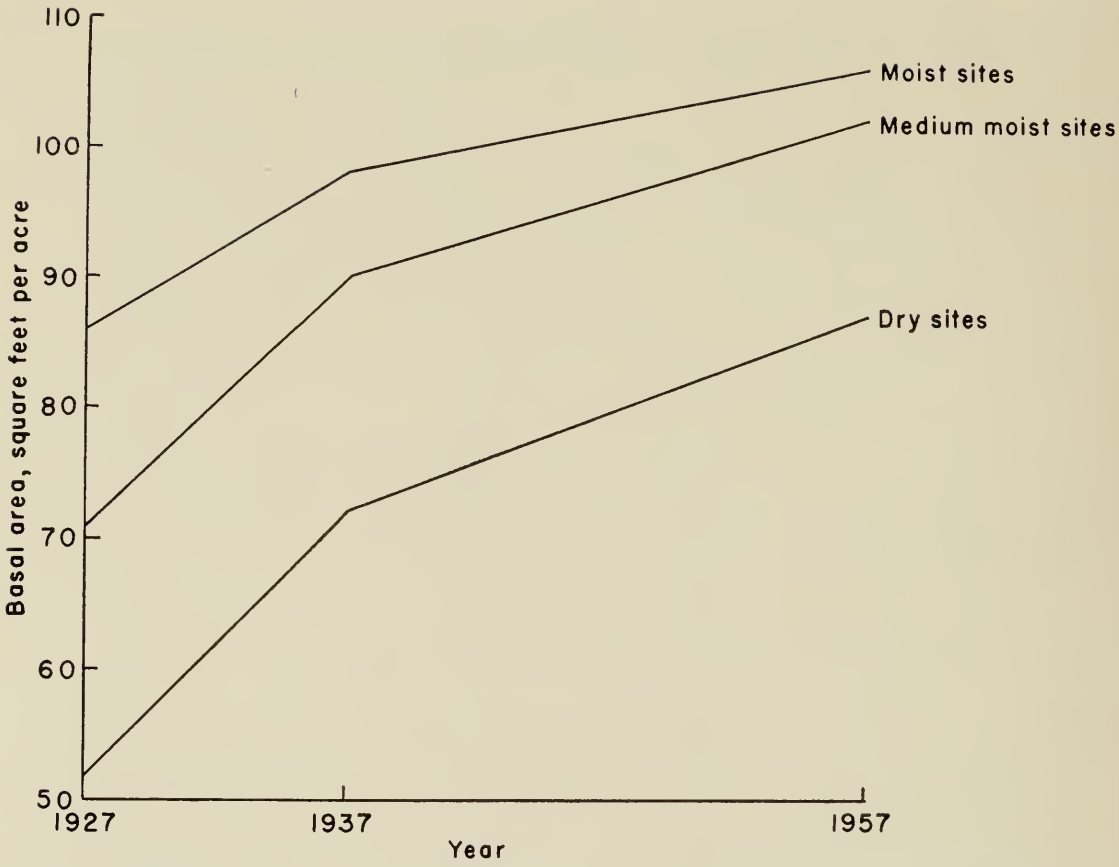

Figure 3. Basal area on the combined four tracts, showing different rates of increase in the different soil drainage classes during the 30 years.

the medium sites on Reeves and caused the lesser increases noted from 1937 to 1957 (Table 4). A 32-inch black birch wolf tree on the moist site on Turkey Hill accounts for the great basal area there in 1927; its death resulted in the small increase from 1927 to 1937. Death of the abundant gray birch and aspen on Cox reduced increases on the moist and medium moist sites. Death, probably caused by drought, is the reason given for the small increase from 1927 to 1937 on the less than 0.1 acre of dry sites on Turkey Hill. Despite these discrepancies, total basal area did not differ significantly among tracts.

Only a few of the 36 species differed greatly among tracts in their proportion of total basal area. The basal area of chestnut oak was remarkably great on Cabin, that of yellow birch on Turkey Hill, and that of black birch on Cox was notably less. Aspen, gray birch and blue beech were present in great proportion on Cox in 1927, much occurring on part of the tract formerly cleared. However, by 1957, death of these pioneer species eliminated this singularity in Cox.

In 1927 fully 83 per cent of the total basal area on the tracts was oaks, maples, yellow and black birches, white ash, tuliptree, and pignut and shagbark hickories. By 1957 it had risen to a striking 94 per cent!

White oak, red maple, yellow birch, white ash, and pignut hickory all decreased, the other species listed above either increased or maintained the same proportion. The greatest proportional increases were made by the red, black, and scarlet oaks which increased from 21 per cent in 1927 to 35 per cent in 1957. In 1957, red oak contributed one-fifth of the total basal area, and on Cox where its basal area was greatest, it comprised fully 26 per cent. The other 16 major species and the seven minor species contributed only 6 per cent of the total basal area in 1957 and of these only beech increased noticeably from 1927 to 1957.

Of the more important major species the basal area of red maple, sugar maple, yellow birch, and white ash was greatest on the moist sites; that of red oak and chestnut oak on the medium moist sites; and that of white oak, black oak, scarlet oak, black birch, and pignut hickory on the dry sites (Table 5). Tuliptree and shagbark hickory were represented most on the moist and medium moist sites. In 1957 the five oaks comprised 30 per cent of the total basal area on the moist sites, 55 on the medium moist and 66 on the dry. From 1927 to 1957 the proportion of total basal area increased on all sites for oaks, except white oak, which decreased on the medium moist and dry sites.

From 1927 to 1957 black birch increased only on the dry sites, but had the hurricane not blown down several trees on the medium moist sites, and had a 32-inch wolf tree not died on the moist site, relative basal area of black birch would likely have increased on all sites. Tuliptree increased on all sites, sugar maple on the moist and medium moist sites, and yellow birch and white ash only on the moist sites. Red maple decreased on all sites. Among the less abundant species beech increased on all sites. Most of the other major tree species and all of the small tree species decreased on all sites.

With the muck sites excluded, the basal area was greatest on the moist sites, and decreased with decreasing soil moisture, but the 30-year increase was greater on the dry than on the moist sites. Greater diversity of species occurred and was maintained on the moist sites. In general, the stands are becoming increasingly dominated by oaks, particularly on the drier sites, with red, black, and scarlet oak increasing most.

Distribution of Diameter

To determine the proportion of trees of different sizes and the changes with time, they were grouped into four classes: (1) small sapling, 0.5 to 1.5 inches d.b.h.; (2) large sapling, 1.6 to 5.5; (3) pole, 5.6 to 11.5; and (4) sawtimber, larger than 11.5.

Among the major species the proportion of saplings, small and large, decreased from 91 per cent in 1927 to 69 in 1957, while that of the pole and sawtimber size trees increased from 9 to 31 percent (Table 6). Even though the number of trees differed greatly between tracts, the proportion of trees in the same size class differed little between tracts during the 30 years.

The number of trees larger than 11.5 inches d.b.h. increased from 8 per acre in 1927 to 14 in 1937 and 34 in 1957. An analysis of some study plots in mixed hardwoods in Connecticut (Hawes, 1933) and stand tables for the upland oak forests of the United States (Shnur, 1937) indicate that 70 to 80 trees per acre of this size may be expected in the mature stand. By this criterion the 34 sawtimber trees per acre in 1957 indicated that these stands were only approaching maturity. During 30 years the number of trees atttaining sawtimber size increased from about 6 per decade to about 10 on all tracts except Turkey Hill. The lesser increase from 1937 to 1957 on Turkey Hill is attributed to windthrow of some larger trees during the 1938 hurricane.

Of the minor species on the four tracts nearly all were less than 5.6 inches d.b.h. and three-quarters were less than 1.6 inches in both 1927 and 1957. The proportion of large saplings increased from 1927 to 1937, but decreased by 1957.

From 1927 to 1957 more than three-quarters of the increase in number of trees per acre larger than 11.5 inches d.b.h. was by oak. Red, black, and scarlet oak accounted for 60 per cent of this increase (Table 7). Among the other species increases as per cent of the total were black birch, 8; tuliptree, 7; yellow birch, 4; red maple, 2; sugar maple, 1; and pignut hickory, beech, basswood, and elm combined, 1.5. Red maple was the most abundant, by far, of the major

Table 5. Basal area of major and minor species (per cent of total), all tracts

	Moist sites			Medium moist sites			Dry sites			All sites		
	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957
Major species												
Sugar Maple	4.4	4.4	5.0	1.3	1.3	1.5	.2	.2	.2	1.8	1.8	2.0
Red Maple	24.5	24.3	20.2	10.8	10.2	9.5	11.2	9.5	6.7	14.4	13.5	11.5
Red Oak	6.7	10.2	16.8	14.2	17.2	22.3	9.2	12.2	16.3	12.0	15.1	20.4
Black Oak	1.7	2.1	2.7	4.4	5.8	8.2	11.8	15.3	20.3	4.5	6.1	8.6
Scarlet Oak	1.6	2.5	2.7	5.0	5.7	7.2	7.4	9.3	11.7	4.5	5.4	6.8
White Oak	1.8	2.0	2.1	10.4	10.0	8.5	15.5	17.0	13.7	9.0	9.2	7.9
Chestnut Oak	3.2	4.6	5.8	7.8	8.6	9.1	3.9	3.1	3.8	6.4	7.2	7.8
Yellow Birch	15.2	15.8	16.6	6.7	6.7	5.7	1.1	.8	.7	7.8	7.7	7.0
Black Birch	10.6	8.1	10.4	13.4	13.4	13.1	15.4	15.4	15.9	12.9	12.5	12.9
White Ash	4.5	4.9	4.7	4.1	3.7	2.5	2.0	1.8	.3	4.0	3.8	2.8
Tuliptree	2.4	3.4	4.2	3.2	3.8	4.1	.2	.3	.6	2.7	3.3	3.6
Pignut Hickory	.4	.4	.5	2.1	1.9	1.8	4.7	4.4	2.9	2.0	1.9	1.7
Shagbark Hickory	.8	.8	1.3	1.1	1.0	1.0	.8	.8	.7	1.0	.9	1.0
Beech	.1	.3	.7	.3	.3	.5	3.1	2.8	3.8	.6	.6	.9
Mockernut Hickory	.1	<.1	0	1.0	.9	1.0	1.3	1.3	1.1	.8	.7	.8
Bitternut Hickory	.1	<.1	0	.1	<.1	<.1	0	0	0	<.1	<.1	<.1
Elm	1.9	1.8	1.7	.1	.1	<.1	<.1	0	0	.5	.4	.4
Sassafras	.4	.2	.2	.5	.5	.4	.5	.2	.1	.5	.4	.3
Basswood	.6	.7	.2	.3	.3	.3	0	0	0	.3	.3	.2
Tupelo	.3	.4	.3	.2	.2	.1	<.1	<.1	<.1	.2	.2	.2
Aspen	6.0	5.1	0	1.9	1.5	.1	2.7	1.4	0	2.8	2.2	.1
White Birch	0	0	0	.2	.2	.2	0	0	0	.1	.1	.1
Black Cherry	.9	.2	.1	.2	.1	0	.5	.1	0	.4	.1	<.1
Butternut	.4	<.1	0	.4	.2	0	.4	.1	0	.4	.1	0
Black Ash	.5	.4	0	<.1	<.1	0	0	0	0	.1	.1	<.1
Black Locust	0	0	0	0	0	0	<.1	.1	.2	<.1	<.1	<.1
White Pine	0	<.1	0	.4	.4	<.1	0	0	0	.3	.3	<.1
Red Cedar	0	0	0	.4	.1	<.1	.4	0	0	.3	<.1	<.1
Hemlock	<.1	<.1	.1	<.1	<.1	<.1	0	0	0	<.1	<.1	<.1

Minor species	Moist sites			Medium moist sites			Dry sites			All sites		
	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957
Gray Birch	4.7	2.7	.1	4.0	2.3	.1	4.3	2.2	0	4.1	2.3	.1
Blue Beech	3.4	2.4	1.9	2.4	1.4	.6	1.3	.5	.1	2.5	1.5	.8
Hophornbeam	1.2	.9	.7	.9	.6	.3	.6	.4	.2	.9	.6	.4
Dogwood	.3	.2	.3	1.2	1.1	.9	.5	.4	.2	.9	.8	.7
Witch-Hazel	1.0	.7	.9	.9	.7	.4	.3	.1	.1	.9	.6	.5
Shadbush	.3	.4	.1	.3	.2	<.1	.4	.4	.2	.3	.2	.1
Chestnut	<.1	<.1	.1	.1	<.1	.2	.4	<.1	.2	.1	<.1	.1
Basal area (sq. ft./acre)												
All species	85.9	98.2	106.1	70.8	90.1	101.6	52.1	71.8	87.3	70.4	88.4	99.5

Table 6. Number and proportion of trees by diameter, all tracts

	DIAMETER CLASS											
	0.5″ to 1.5″			1.6″ to 5.5″			5.6″ to 11.5″			Greater than 11.5″		
	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957
	Trees/acre											
Major species	470	218	156	509	400	203	86	129	122	8	14	34
Minor species	349	169	169	132	102	52	1	2	<1	0	0	0
	Per cent of total											
Major species	44	29	30	47	53	39	8	17	24	1	2	7
Minor species	72	62	76	27	37	23	<1	1	<1	0	0	0

Table 7. Diameter class distribution by species (trees/acre), all tracts

	DIAMETER CLASS														
	0.5" to 1.5"			1.6" to 5.5"			5.6" to 11.5"			Greater than 11.5"			All classes		
	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957
Major species															
Sugar Maple	24.0	18.6	17.5	14.0	14.8	16.0	1.4	2.0	2.3	.1	.1	.3	39.4	35.6	36.1
Red Maple	139.8	74.2	57.4	117.9	105.1	67.5	11.1	17.0	19.8	.7	.7	1.2	269.5	197.0	145.9
Red Oak	33.3	10.8	3.2	52.0	36.6	11.9	12.6	20.5	18.1	1.6	2.9	10.1	99.5	70.8	43.3
Black Oak	9.8	4.7	.4	21.3	12.2	3.0	4.7	9.4	8.2	.4	1.3	4.3	36.1	27.6	15.8
Scarlet Oak	2.5	.7	.5	11.9	6.0	.9	6.8	8.8	7.2	.2	1.0	3.5	21.5	16.5	12.0
White Oak	60.5	20.1	2.6	60.8	46.3	8.9	8.2	13.0	12.1	.5	1.1	2.4	130.0	80.5	26.1
Chestnut Oak	6.7	4.8	4.3	14.9	8.8	3.4	7.8	9.3	7.7	1.2	1.9	3.7	30.5	24.9	19.0
Yellow Birch	37.9	20.3	21.6	43.4	38.3	27.1	7.2	10.8	10.4	.8	1.3	1.7	89.3	70.6	60.7
Black Birch	52.5	25.2	22.7	60.5	55.1	30.8	10.9	16.4	19.1	1.6	1.9	3.8	125.5	98.6	76.4
White Birch	.2	.1	.2	.4	.3	.2	.1	.2	.3	0	0	0	.7	.6	.7
White Ash	30.8	11.1	5.6	33.6	25.8	8.3	2.1	4.6	5.3	.4	.4	.3	66.9	41.9	19.5
Black Ash	.3	0	.1	.3	.2	.1	.3	.3	.1	0	0	0	.9	.5	.3
Pignut Hickory	28.4	9.4	1.7	17.9	15.0	5.9	1.2	1.9	2.6	.1	.1	.2	47.5	26.4	10.5
Shagbark Hickory	2.3	.4	.3	6.3	5.1	2.4	1.2	1.7	2.2	0	0	0	9.8	7.1	5.0
Mockernut Hickory	6.7	2.9	1.1	6.1	5.7	3.1	.5	.9	1.4	.1	0	.1	13.4	9.5	5.6
Bitternut Hickory	1.5	.4	.1	.8	.7	0	0	0	.1	0	0	0	2.2	1.1	.2
Tuliptree	2.3	.7	.3	5.8	3.0	.9	3.4	4.4	2.4	.3	1.2	2.1	11.9	9.2	5.7
Beech	9.7	7.7	10.3	4.0	5.1	6.6	.2	.3	.4	.1	.1	.2	14.0	13.2	17.5
Black Cherry	4.4	.2	0	6.4	1.5	.1	0	0	0	0	0	0	10.8	1.7	.1
Basswood	1.0	.1	0	2.0	1.3	.2	.1	.5	.4	0	.1	.1	3.1	1.9	.7
Elm	1.7	.7	.1	3.0	2.1	1.2	.9	.9	.9	0	0	.1	5.6	3.7	2.2
Butternut	.9	.1	0	3.3	.7	0	.3	.2	0	0	0	0	4.5	1.0	0
Tupelo	5.1	3.4	1.8	2.8	2.2	2.1	.1	.1	.1	0	0	0	8.0	5.7	4.1
Black Locust	.2	0	0	.1	.1	0	0	0	.1	0	0	0	.3	.1	.1
Sassafras	6.4	1.3	4.2	7.2	5.0	1.8	.2	.4	.6	0	0	0	13.8	6.6	6.6
White Pine	0	.1	.3	0	0	.4	.2	.1	0	.1	.2	0	.3	.4	.7
Hemlock	.1	0	0	.2	.3	.2	0	0	.1	0	0	0	.3	.3	.3
Red Cedar	.6	0	0	2.2	0	0	.5	.2	.1	0	0	0	3.3	.2	.1
Aspen	.4	.1	.1	9.5	2.8	0	4.4	5.7	.3	0	0	0	14.3	8.6	.4
All major species	469.9	217.8	156.3	508.7	400.0	202.9	86.0	129.5	122.3	8.0	14.2	34.0	1072.7	761.7	515.7

Minor species	0.5″ to 1.5″			1.6″ to 5.5″			5.6″ to 11.5″			Greater than 11.5″			All classes		
	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957
Gray Birch	14.7	.9	0	54.7	25.2	.6	.9	1.4	.1	0	0	0	70.2	27.4	.7
Blue Beech	153.5	64.6	33.1	33.3	34.6	18.0	0	0	0	0	0	0	186.8	99.2	51.1
Witch-Hazel	108.8	69.5	78.9	11.3	7.6	7.2	0	0	0	0	0	0	120.1	17.1	86.1
Dogwood	26.2	16.9	13.5	14.1	16.6	15.3	.1	.1	0	0	0	0	40.4	33.6	28.8
Hophornbeam	20.2	7.3	7.0	14.4	11.9	7.9	.2	.4	.2	0	0	0	34.8	19.5	15.1
Shadbush	14.0	7.8	1.3	4.3	5.7	1.2	0	.1	0	0	0	0	18.3	13.6	2.4
Chestnut	11.8	1.6	34.8	.5	0	1.5	0	0	0	0	0	0	12.2	1.6	36.2
All minor species	349.1	168.6	168.6	132.5	101.6	51.7	1.2	2.0	.3	0	0	0	482.8	272.0	220.4

species and was the most numerous of the saplings, but few were sawtimber size: 0.7 trees per acre in 1927 and 1937 and only 1.2 in 1957. The number of white ash in this class decreased from 0.4 to 0.3 trees per acre during 30 years.

White and red oak saplings were numerous in 1927 but not in 1957. Sugar maple saplings were also numerous and their numbers decreased little during 30 years. Although beech was few in numbers, it was the only species to increase in all size classes.

Minor species comprised 43 per cent of the small saplings in 1927 and 52 in 1957 (Table 6). They constituted about 20 per cent of the large saplings in 1927 and 1957. Only an occasional tree of gray birch, dogwood, hophornbeam, and shadbush exceeded 5.5 inches, and most of these had died by 1957. Blue beech was the most abundant of the minor species in the small sapling size, and blue beech and gray birch were the most numerous in the large sapling size.

During the 30 years the total number of trees of the major species was reduced to slightly less than half of those present in 1927. The proportion of trees less than 5.6 inches d.b.h. decreasd by nearly two-thirds, while those larger increased by nearly two-thirds, and the number of those more than 11.5 inches more than quadrupled. Thus, a forest of large trees is developing rapidly from the dense sapling growth of three decades ago.

Height In 1957

The height of dominant and codominant trees at a given age, site index, indicates the quality of a site for forest growth.

In 1957 when the stands were 55 to 70 years old, the average height of dominant and codominant trees of all species on the four tracts was 68 feet. Average height was practically equal, 68 feet, on the moist and medium moist sites which comprised 85 per cent of the sample area (Table 8). The average dominant and codominant was about 4 feet shorter on the dry sites and 24 feet shorter on muck than on the moist and medium moist sites.

The taller dominant and codominant trees were usually sugar maple, all oaks except white oak, black birch, pignut and shagbark hickory, and tuliptree. Red maple, white oak, yellow birch, and white ash were usually shorter.

Average height of all species on all moisture classes was significantly less on Turkey Hill than on the three other tracts. This difference is attributed to the 1938 hurricane for two reasons. Many larger trees disappeared on Turkey Hill between 1937 and 1957 and much of the topography of Turkey Hill exposed trees to hurricane winds of 1938. After the probable windthrow of many larger trees on Turkey Hill, many shorter trees likely assumed a dominant or codominant position in the canopy, and the height of these would be less in 1957 than the dominant or codominant trees which they replaced.

The site quality of these four similar tracts may be determined by comparing their height and age to a range of sites. The average height of the dominant and codominant trees in 1957 at ages ranging from 55 to 70 years on the moist and medium moist sites on the four tracts indicates that these sites are slightly better than medium quality sites in the oak forests of Pennsylvania (McIntyre, 1933). On the dry sites of the four tracts the average height was slightly less than on the medium quality sites in Pennsylvania. The average height of all sites on Turkey Hill was less than that on the medium quality sites in Pennsylvania, but this is likely due in part at least to windthrow of some of the larger trees by the 1938 hurricane.

Therefore, the site quality of the four tracts, excluding muck, was medium or slightly better.

Table 8. Height in feet of dominant and codominant trees in 1957 (Number in parentheses is the number of trees in the sample)

	Turkey Hill			Cox, Reeves, and Cabin			All Tracts		
	Moist[a]	Medium moist	Dry	Moist	Medium moist	Dry	Moist	Medium moist	Dry
Sugar Maple	60(1)	67(2)	.....	80(3)	70(1)	.....	75(4)	68(3)	.....
Red Maple	60(8)	58(6)	.....	68(9)	63(9)	....	64(17)	61(15)	.....
Red Oak	61(4)	64(18)	64(1)	70(22)	73(105)	67(15)	69(26)	72(123)	67(16)
Black Oak	.....	67(11)	.....	74(4)	71(40)	64(22)	74(4)	70(51)	64(22)
Scarlet Oak	.....	54(7)	.....	75(4)	74(39)	65(12)	75(4)	71(46)	65(12)
White Oak	.....	61(14)	51(1)	63(3)	69(24)	63(7)	63(3)	66(38)	62(8)
Chestnut Oak	58(2)	65(8)	47(2)	81(4)	71(42)	61(1)	73(6)	69(50)	52(3)
Yellow Birch	61(12)	60(9)	.....	66(3)	62(2)	.....	62(15)	60(11)	.....
Black Birch	67(6)	62(19)	.....	74(9)	68(23)	71(3)	71(15)	65(42)	71(3)
White Ash	53(3)	57(3)	.....	71(5)	67(6)	.....	64(8)	64(9)	.....
Pignut Hickory	.....	66(3)	59(1)	76(1)	71(6)	64(4)	76(1)	69(9)	63(5)
Shagbark Hickory	62(1)	.....	.....	71(3)	70(2)	71(1)	69(4)	70(2)	71(1)
Mockernut Hickory	.....	.....	.....	.....	66(6)	.....	.....	66(6)	.....
Tuliptree	71(3)	73(6)	.....	80(3)	76(18)	71(1)	75(6)	76(24)	71(1)
Elm	60(2)	.....	.....	.....	.....	.....	60(2)	.....	.....
All species[b]	62(42)	62(106)	54(5)	72(73)	71(323)	66(66)	68(115)	69(429)	65(71)
							All sites, 68(615)		

[a] On muck, which was represented on Turkey Hill only, the average height of five red maples was 47 feet, and the height of one yellow birch was 42 feet, and of one elm, 34 feet. The average height of the seven trees was 45 feet.

[b] The heights of others less important were: Turkey Hill, a blue beech on moist site, 20 feet and a dogwood on medium moist, 31 feet; Cox, a basswood on medium moist, 76 feet; Reeves, on dry sites a beech, 76 feet and a black locust, 54; Cabin, on medium moist a white birch, 60 feet and two beech averaging 63.

Species In the Canopy

The crown canopy, composed principally of the dominant and codominant trees, controls the wood. Because the trees were not yet overmature the proportion of dominant and codominant trees of the different species and the changes during the 30 years determine the principal species composition during that period and for some time to come.

The average over all tracts was 267 dominant and codominant trees per acre in 1927 and 114 in 1957 (Table 9). (Crown class was not recorded on Turkey Hill in 1927.) There was no great difference in number of trees comprising the canopy among soil moisture classes, except muck, where the number was less. Numerous gray birch and aspen on Cox largely accounted for the greater numbers of dominants and codominants there in 1927 and 1937. On Turkey Hill the number of dominant and codominant trees increased between 1937 and 1957 after the canopy was disturbed by the 1938 hurricane.

The proportion of the different species in the canopy differed little among tracts except for an abundance of chestnut oak on Cabin and yellow birch on Turkey Hill, a scarcity of black birch on Cox and white ash on Cabin, and an abundance of the pioneers, aspen and gray birch, on Cox during the first two decades.

In 1957 on the moist sites the most abundant species in the canopy were red and chestnut oak, red maple, yellow and black birch, and white ash. All except red maple and white ash increased significantly as per cent of the total from 1927 to 1957. Significant changes for other species less abundant in 1957 were increase in elm and decrease in aspen, black cherry, and gray birch. On the medium moist sites all five oaks, red maple, and black birch were most abundant in 1957. The only significant changes among these were increase in red and chestnut oak and decrease in red maple. The less abundant white ash, aspen, and gray birch all decreased significantly. On the dry sites the five oaks, black birch, and pignut hickory were most abundant in the canopy in 1957. Significant changes were increases in all oaks except white and decrease in black birch. Of those less abundant in 1957, red maple, white ash, aspen, and gray birch had decreased significantly during the three decades.

Although red maple increased on the moist sites from 19 per cent in 1927 to 30 in 1937, it decreased to 22 in 1957. On muck it decreased from 83 per cent in 1937 to 67 in 1957. The decrease of red maple on the moist sites from 1937 to 1957 and on the medium moist dry sites from 1927 to 1957 indicated that it was becoming less important in the canopy.

On all moisture classes of all tracts, however, the canopy became increasingly dominated by oaks; the average proportion increased from 37 per cent in 1927 to 55 in 1957. During the three decades the greatest increase, from 45 per cent to 84, occurred on the dry sites, of course. The oaks were less abundant on the medium moist sites, where the increase was from 40 to 57 per cent, and still less abundant on the moist sites, where the increase was only from 17 to 24 per cent, during the 30 years. All of these increases from 1927 to 1957 were statistically significant. However, increases were relatively greater during the first compared to the last two decades.

The proportion of yellow and black birch increased significantly from 1927 to 1957; there was little change during the first decade, but a great increase during the next two decades.

Several less abundant species disappeared from the canopy through death or failure to grow as rapidly as others (Table 9).

The great increase of oak in the canopy on the drier sites decreased the diversity of species in the canopy, but on moist sites the lesser increase in oak

Table 9. Dominant and codominant trees in the canopy (per cent of total), all tracts

	Moist sites			Medium Moist sites			Dry sites			All sites		
	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957
Major species												
Sugar Maple	3.5	2.6	4.0	1.1	.7	1.0	.3	0	0	1.4	1.0	1.4
Red Maple	18.8	30.1	21.9	10.9	8.0	7.5	10.6	2.9	.8	12.2	12.2	9.8
Red Oak	7.9	12.0	14.9	15.3	19.3	22.5	10.9	17.0	21.1	13.3	17.6	20.8
Black Oak	1.1	1.9	2.0	4.9	6.3	8.1	12.8	17.5	26.3	5.5	6.7	9.0
Scarlet Oak	2.7	2.6	2.5	5.1	6.9	8.0	8.1	14.0	15.8	5.1	6.9	7.8
White Oak	2.2	2.6	1.5	8.3	8.2	8.5	12.5	18.1	14.3	7.9	8.3	7.8
Chestnut Oak	3.0	4.1	6.5	6.2	8.8	10.4	.9	3.5	6.8	4.8	7.3	9.2
Yellow Birch	9.2	7.9	16.4	4.0	4.7	4.4	.6	0	0	4.4	4.6	6.0
Black Birch	4.3	6.0	11.9	13.4	14.1	15.5	16.6	11.1	6.0	12.3	12.2	13.6
White Ash	6.0	6.8	7.0	5.5	4.0	2.7	2.2	2.9	0	5.1	4.4	3.2
Tuliptree	1.9	3.0	3.0	3.0	4.6	4.0	.3	.6	.8	2.4	3.8	3.4
Pignut Hickory	.3	.4	1.0	1.8	1.7	2.1	3.7	3.5	5.3	1.9	1.6	2.2
Shagbark Hickory	1.1	1.1	2.5	1.3	1.4	1.3	.6	1.2	.8	1.2	1.3	1.4
Mockernut Hickory	0	0	0	1.6	1.3	1.8	1.2	.6	.8	1.2	1.0	1.4
Bitternut Hickory	0	0	0	.1	.1	.1	0	0	0	<.1	.1	.1
Elm	.5	1.1	3.0	0	0	0	0	0	0	.1	.3	.7
Beech	.3	.4	.5	.2	.2	.5	.6	1.2	.8	.3	.3	.5
Aspen	14.1	13.2	0	3.3	2.9	.4	5.0	2.3	0	5.5	4.6	.3
White Birch	0	0	0	.1	.2	.2	0	0	0	.1	.1	.2
Basswood	.5	.4	0	.2	.3	.1	0	0	0	.2	.3	.1
Tupelo	0	0	0	.1	.1	.1	0	0	0	.1	.1	.1
Black Locust	0	0	0	0	0	0	0	0	.8	0	0	.1
Sassafras	.3	0	0	.3	.7	.2	0	0	0	.2	.5	.2
Black Ash	.5	.4	0	0	0	0	0	0	0	.1	.1	0
Butternut	.3	0	0	.5	.2	0	.6	0	0	.5	.1	0
Black Cherry	1.6	.4	0	.2	.2	0	.3	0	0	.5	.2	0
White Pine	0	0	0	.1	.3	0	0	0	0	<.1	.2	0
Red Cedar	0	0	0	0	0	0	.3	0	0	<.1	0	0

Table 9 (Continued). Dominant and codominant trees in the canopy (per cent of total), all tracts

	Moist sites			Medium Moist sites			Dry sites			All sites		
Minor species	1927	1937	1957	1927	1937	1957	1927	1937	1957	1927	1937	1957
Gray Birch	19.6	2.6	.5	11.7	4.8	0	11.2	3.5	0	13.0	4.2	.1
Blue Beech	0	0	.5	.1	0	.2	0	0	0	<.1	0	.3
Dogwood	0	0	0	.2	0	.4	0	0	0	.1	0	.3
Hophornbeam	.3	.4	.5	.5	.2	.1	0	0	0	.4	.2	.2
Chestnut	0	0	0	0	0	0	.3	0	0	<.1	0	0
No./acres, all species	313	152	115	263	154	119	241	120	94	267	148	114

and the increasing importance of other species, particularly yellow and black birch, provided greater diversity. Red maple, one of the most important species in the canopy in 1927, decreased in importance.

Proportion of Trees Growing From Subordinate To Dominant Positions

To learn whether trees in a subordinate position in the stand were attaining a more dominant position, the number of suppressed or intermediate trees in 1927 which became dominants or codominants in 1957 were determined.

Cox, Reeves, and Cabin tracts averaged only 8 trees per acre attaining more dominant positions in the stands, whereas on Turkey Hill, where the hurricane of 1938 blew down large trees, 44 trees grew from subordinates in 1927 to dominants and codominants in 1957. Black birch contributed the greatest number, 19 per cent on both Turkey Hill and the other tracts. Red maple was next with 16 per cent on Turkey Hill and 18 on the others. The oaks, collectively, comprised 32 per cent of the total on Turkey Hill and 37 on the other tracts; red, chestnut, and white oaks contributed most on Turkey Hill and red and black oaks most in the other tracts.

Clearly, few subordinate trees can improve their position in stands such as these unless the canopy is broken.

Proportion of Single Stems to Known Sprouts

All trees which were members, survivors, or recruits of a sprout group were classified as sprouts. The remainder were classified as single trees or stems because they had not visibly been members of a sprout group during the 30 years. Some of these single trees undoubtedly originated as sprouts, but their origin was not apparent during 1927 to 1957. The true proportion of trees originating as seedlings, therefore, is equal to or less than the percentage of single trees in Tables 10 and 11.

The number of single trees of the major species generally exceeded that of the known sprouts (Table 10). After the 1938 hurricane ingrowth of small trees was great on the muck on Turkey Hill, particularly sprouts of red maple; consequently the proportion of single trees decreased from 61 per cent in 1927 to 46 in 1957.

Although the proportion of single trees of major species was slightly less on moist than on other sites, the proportion varied surprisingly little from 0.6 on the four tracts and three moisture classes during the 30 years (Table 10).

The proportion of single trees and the change in proportion differed for

Table 10. Occurrence of single trees (per cent of all trees) on undisturbed sites

	Moist sites		Medium moist sites		Dry sites	
	1927	1957	1927	1957	1927	1957
			Major species			
Turkey Hill	61	62	72	68	49	52
Cox	52	45	64	60	62	62
Reeves	64	60	62	62	67	63
Cabin	55	59	66	64	....	....
All tracts	57	56	65	63	64	62
			Minor species			
All tracts	34	33	34	43	36	57

Table 11. Occurrence of single trees (per cent of all trees), all tracts

	Moist sites		Medium moist sites		Dry sites	
Species	1927	1957	1927	1957	1927	1957
Sugar Maple	58	79	64	68	44	33
Red Maple	37	37	50	51	35	45
Red Oak	70	63	73	66	71	66
Black Oak	67	83	83	87	81	80
Scarlet Oak	80	86	68	80	90	88
White Oak	78	83	80	83	79	69
Chestnut Oak	69	73	66	65	64	63
Yellow Birch	43	42	41	45	42	87
Black Birch	59	73	63	75	58	68
White Ash	68	57	67	62	82	43
Pignut Hickory	100	100	91	84	90	83
Shagbark Hickory	71	70	64	62	82	75
Mockernut Hickory	67	....	93	96	75	67
Tuliptree	61	67	62	57	100	100
Beech	67	54	47	55	17	40
Elm	85	87	83	100	100	....
Tupelo	91	85	93	90	100	100
Sassafras	89	60	92	91	96	87
All major species	57	56	65	63	64	62

some of the major tree species. Among the more abundant species, single trees were predominant among the oaks, sugar maple, black birch, white ash, pignut, shagbark and mockernut hickory, tuliptree, elm, tupelo, and sassafras and least among red maple, yellow birch, and beech (Table 11).

On the moist sites the greatest changes in proportion of single trees were the significant increases in sugar maple and black birch. On the medium moist sites the greatest changes were the significant increase in proportion of single trees in black birch and the decrease in red oak. On the dry sites greatest changes in proportion of single trees were the significant increases in red maple and beech.

The change in proportion of single stems among the large dominant and codominant trees of the canopy was obscured by averaging these relatively few, but highly important, individuals with the more numerous intermediate and suppressed trees. Fifty-nine per cent of dominant and codominant trees were single stemmed in 1927 and 69 per cent in 1957. This increase is statistically significant at the 5 per cent level. Single trees, therefore, became increasingly more numerous than known sprouts in the canopy. Among the intermediate and suppressed trees, the proportion of single trees decreased little from 63 per cent in 1927 to 60 in 1957.

The proportion of single trees which were dominant or codominant was greatest among the oaks except chestnut oak, sugar maple, black birch, pignut and mockernut hickory, and aspen and least among red maple, yellow birch, and tuliptree. During the 30 years the proportion of single trees among the dominants and codominants increased for all species except scarlet oak; significant increases occurred in red maple, yellow and black birch, and white ash.

Among the intermediate and suppressed trees, single stems predominated among the oaks, sugar maple, black birch, white ash, and the hickories, and were least among red maple, yellow birch, and beech. The proportion of single trees increased significantly in sugar maple, yellow and black birch, and beech. Significant decreases occurred in red oak and pignut hickory.

The increase in proportion of single-stemmed dominant and codominant trees accompanied by the decrease in the dominant and codominant sprouts was a significant change during the 30 years.

Mortality

In 1927 these stands were relatively young, and more than 1500 trees per acre competed for light and moisture. During the following three decades, as same trees continued to grow, large numbers of those less able to compete died. One-third of the trees of the major species present died during the decade following 1927, and of those present in 1937 one-fourth per decade died during 1937 to 1957. Fifty-one per cent of the trees of the minor species died from 1927 to 1937 and 33 per cent per decade from 1937 to 1957.

Thus death decreased the number of trees of the major species from 1073 per acre in 1927 to 516 in 1957. The greatest decrease was 1292 to 522 on Cox tract and the least, 773 to 556, on Turkey Hill. The lesser decrease on Turkey Hill is attributed to both fewer trees initially and greater ingrowth following blowdown during the 1938 hurricane. The number of trees of the minor species decreased from 483 to 220 per acre on the four tracts during the 30 years. The greatest decrease, 805 to 179, occurred on Cox and the least, 262 to 226, on Cabin. The greatest mortality was among white oak, white ash, pignut and bitternut hickory, black cherry, basswood, butternut, sassafras, red cedar, and aspen of the major species and among gray birch, blue beech, chestnut, and shadbush (Table 12).

Rate of mortality in proportion of the trees dying differed little among moist, medium moist and dry sites, for both major and minor species or even for individual species (Table 12). As the decades passed mortality decreased on all sites except muck, where it increased due to the 1938 hurricane. Single trees and sprouts of the major species died in equal proportions during the 30 years and only slightly more single trees than sprouts of the minor species died.

Among the major species mortality was slightly greater in the sprout groups of yellow and black birch, sugar and red maple, and scarlet oak, but it was greater in the single trees of red oak, and beech. Among the minor species mortality was greatest among the single trees of witch-hazel and shadbush and among the sprout members of dogwood.

Mortality was high among both the major and minor species during the first decade but has decreased since then and differed little between the moist, medium moist, and dry sites.

Ingrowth

While many trees were dying during the 30 years, others appeared and those which grew to at least 0.6 inch d.b.h. in 1937 or 0.5 in 1957 were classified as ingrowth. Average ingrowth for the major species was 54 trees per acre from 1927 to 1937 and 66 per decade from 1937 to 1957 (Table 13). The ingrowth per decade increased significantly on Turkey Hill from 66 to 94 and on Cox from 29 to 62, while it decreased insignificantly on the other tracts. The increase in ingrowth on Turkey Hill followed the 1938 hurricane and on Cox occurred while large numbers of gray birch and aspen were dying.

If, however, ingrowth is considered as a percentage of the total number of trees present in 1937 and 1957, then the ingrowth increased significantly on all tracts. During 1927 to 1937 and 1937 to 1957 the ingrowth on Turkey Hill was 11 and 34, on Cox 4 and 24, on Reeves 7 and 19, and on Cabin 10 and 27 per cent.

Table 12. Mortality, all tracts

Major species	Moist sites				Medium moist sites				Dry sites			
	No. trees/acre		Per cent dying		No. trees/acre		Per cent dying		No. trees/acre		Per cent dying	
	1927	1937	1927 to 1937	1937 to 1957	1927	1937	1927 to 1937	1937 to 1957	1927	1937	1927 to 1937	1937 to 1957
Sugar Maple	75	72	14	34	37	32	20	32	11	9	19	31
Red Maple	269	198	31	45	266	195	32	48	294	204	34	51
Red Oak	70	56	30	39	110	76	34	44	97	70	32	47
Black Oak	10	7	33	50	32	24	29	41	94	76	25	50
Scarlet Oak	8	8	7	50	21	15	29	25	41	35	15	38
White Oak	39	19	51	61	144	85	45	73	189	144	28	69
Chestnut Oak	16	19	10	58	36	28	30	42	23	18	39	42
Yellow Birch	163	138	27	36	89	68	30	44	8	6	33	56
Black Birch	44	36	22	35	140	109	27	43	168	136	27	39
White Ash	63	43	36	56	77	46	43	67	23	21	23	83
Pignut Hickory	11	8	32	57	47	23	54	72	101	69	38	53
Shagbark Hickory	8	6	21	18	11	8	30	30	8	6	18	67
Mockernut Hickory	3	1	67	100	14	10	31	44	22	18	22	52
Tuliptree	10	10	11	53	14	11	25	45	2	1	33	0
Beech	2	2	67	33	15	14	24	47	25	27	14	39
Black Cherry	31	5	83	89	6	1	86	100	11	1	93	100
Basswood	3	3	17	67	4	2	46	64	0	0	.....	.....
Elm	22	15	36	48	2	1	42	62	1	0	100	.....
Butternut	3	1	83	100	4	1	83	100	8	2	82	100
Tupelo	19	20	29	31	6	4	34	52	3	1	60	0
Sassafras	11	5	58	75	14	7	49	69	18	6	69	44
Red Cedar	0	0	.....	.....	4	<1	93	50	3	0	100	.....
Aspen	35	23	34	100	8	6	34	92	20	7	64	100
Other major species	5	4	33	86	5	3	43	57	2	1	67	0
All major species	924	693	31	45	1107	770	35	50	1175	860	32	53

Minor species	Moist sites				Medium moist sites				Dry sites			
	No. trees/acre		Per cent dying		No. trees/acre		Per cent dying		No. trees/acre		Per cent dying	
	1927	1937	1927 to 1937	1937 to 1957	1927	1937	1927 to 1937	1937 to 1957	1927	1937	1927 to 1937	1937 to 1957
Gray Birch	92	34	64	97	67	26	62	97	65	28	59	100
Blue Beech	270	153	48	65	198	102	51	73	49	29	46	80
Witch-Hazel	152	97	64	47	132	86	46	55	37	16	54	48
Dogwood	15	10	33	17	51	44	30	50	22	15	35	64
Hophornbeam	31	19	52	38	40	21	51	53	15	14	32	50
Shadbush	25	20	34	91	16	12	29	92	24	14	47	85
Chestnut	3	1	100	100	11	1	91	60	30	3	95	80
All minor species	589	333	54	61	516	293	50	66	241	120	55	75

Mortality in muck, *1927 to 1937:* Red maple, 9% of 215 trees present in 1927; Yellow birch, none of 6; White ash, none of 37; Black ash, none of 6; Elm, 50% of 37; Tupelo, all of 12; Blue beech, 33% of 18; Witch-hazel and shadbush, none of 6 of each.

1937 to 1957: Red maple, 57% of 215 trees present in 1937; Yellow birch, none of 6; White ash, 14% of 43; Black ash, none of 6; Elm, 33% of 18; Blue beech, 50% of 12; Witch-hazel and shadbush, none of 6 of each.

1927 to 1937: 16% of 314 major species and 20% of 31 small species.

1937 to 1957: 47% of 289 major species and 25% of 25 small species.

Table 13. Ingrowth (trees/acre), all tracts

	Muck sites				Moist sites				Medium moist sites				Dry sites				All sites			
	Total		Ingrowth		Total		Ingrowth		Total		Ingrowth		Total		Ingrowth		Total		Ingrowth	
	1937	1957	1927 to 1937	1937 to 1957	1937	1957	1927 to 1937	1937 to 1957	1937	1957	1927 to 1937	1937 to 1957	1937	1957	1927 to 1937	1937 to 1957	1937	1957	1927 to 1937	1937 to 1957
Major species																				
Sugar Maple	0	0	0	0	72	72	7	24	32	33	3	11	9	10	0	4	36	36	3	12
Red Maple	215	277	18	185	198	136	12	28	195	142	14	41	204	162	11	63	197	146	13	44
Red Oak	0	6	0	6	56	38	7	4	76	45	4	3	70	45	4	8	71	43	5	4
Chestnut Oak	0	0	0	0	19	8	4	1	28	23	3	7	18	13	4	3	25	19	3	5
Other Oaks	0	0	0	0	34	18	0	3	124	53	7	4	255	110	13	5	125	54	7	4
Yellow Birch	6	24	0	18	138	110	19	21	68	60	6	22	6	6	1	3	71	61	7	19
Black Birch	0	6	0	6	36	34	1	10	109	81	7	19	136	114	13	32	99	76	7	19
White Ash	43	80	6	43	43	28	2	9	46	19	2	4	21	5	3	1	42	19	2	5
Pignut Hickory	0	0	0	0	8	3	<1	0	23	11	1	2	69	20	6	1	26	11	2	2
Shagbark Hickory	0	0	0	0	6	6	0	<1	8	5	0	0	6	3	0	1	7	5	0	<1
Mockernut Hickory	0	0	0	0	1	0	0	0	10	7	<1	1	18	8	0	0	9	6	<1	1
Tuliptree	0	0	0	0	10	5	1	1	11	7	0	1	1	2	0	1	9	6	<1	1
Beech	0	0	0	0	2	16	1	15	14	16	2	9	27	28	5	12	13	17	2	10
Sassafras	0	0	0	0	5	8	0	7	7	6	<1	4	6	6	1	2	7	7	<1	4
All Others	25	43	0	25	66	23	3	2	18	7	1	2	13	2	1	0	26	10	2	2
All major species	290	438	25	283	693	506	59	126	770	516	51	131	860	535	63	135	762	516	54	133
Minor species																				
Gray Birch	0	0	0	0	34	1	0	0	26	1	<1	0	28	0	1	0	27	1	1	0
Blue Beech	12	30	0	25	153	89	12	36	102	49	6	21	29	14	3	8	99	51	6	22
Witch-Hazel	6	37	6	31	97	154	29	103	86	84	14	46	16	16	1	8	77	86	15	50
Dogwood	0	0	0	0	10	14	0	6	44	37	8	15	15	8	1	3	34	29	6	12
Hophornbeam	0	0	0	0	19	28	4	16	21	12	1	2	14	13	3	6	19	15	2	5
Shadbush	6	6	0	0	20	3	3	2	12	2	1	1	14	3	1	1	14	2	1	1
Chestnut	0	0	0	0	1	11	1	11	1	42	<1	41	3	44	2	44	2	36	1	36
All minor species	24	73	6	55	333	301	50	173	293	228	32	127	120	99	15	70	272	220	32	126

Among the moisture classes, except muck, the difference in numbers or proportion of new recruits was slight. In muck on Turkey Hill there was a great increase following the 1938 hurricane.

Among species the proportion of ingrowth differed. Over all tracts the average number of new recruits of oak per acre decreased from 15 during the first decade to 7 per decade during the last two decades. On Cox, Reeves and Cabin tracts oak recruits decreased from 14 to 2. On Turkey Hill ingrowth of oak increased only very slightly after the 1938 hurricane, but that of other species increased greatly. Among the more abundant species the average ingrowth of red maple increased from 13 to 22 trees per acre per decade, yellow and black birch each from 7 to 10, sugar maple from 3 to 6, beech from 2 to 5, and sassafras from < 1 to 2. Ingrowth of white ash remained constant at 2.5 as did tuliptree at 0.5. Hickory recruits decreased from 3 to 2 per acre.

To determine age of the numerous red maple recruits 30 trees with d.b.h.'s ranging from 0.5 to 0.9 inch were examined. The number of growth rings near ground line exceeded 20 on two-thirds of the trees but apparently some were false rings. This indicates that some proportion less than two-thirds of the red maples which were ingrowth between 1937 and 1957 originated prior to 1937.

The minor species recruited 32 per acre on the four tracts during the first decade and 63 per decade during the next two decades. Ingrowth increased on all tracts.

Ingrowth as well as the total number of trees of the minor species increased with increasinging soil moisture. Three times as many were recruited on the moist sites as on the dry during the first decade and 2.5 times as many during the next two decades. Recruits of witch-hazel, chestnut, and blue beech were most numerous; witch-hazel and blue beech were most abundant on the moist sites and chestnut on the dry. There were no recruits of gray birch during the last two decades.

Nearly two-thirds of the new trees of the major species were single stems as opposed to those of known sprout origin during the first decade and the proportion decreased only slightly during the next two decades. Among the minor species the proportion of single trees recruited increased significantly from 32 per cent during the first decade to 51 during the next two decades. The proportion of sprouts increased significantly among the recruits of red maple, red oak, white ash, and sassafras, while the proportion of single trees increased significantly among those of chestnut oak and yellow birch. The proportion of single trees increased among the recruits of the minor species except the disappearing gray birch and shadbush; only dogwood increased significantly.

From 1937 to 1957 the proportion of new recruits increased more than three times among the major species and nearly five times among the minor. Of the 36 species present in 1927 only butternut was eliminated through death and failure to recruit new members. Although mortality was great, ingrowth helped to maintain a diversity of species in the understory. Furthermore, if the recruits were to survive in equal proportions among the different species, this would indicate a future trend toward greater diversity of species in the canopy as opposed to the present trend toward increased oak.

Defects

To learn the soundness of the trees in these woodlands some were examined for defect. In 1957 all dominant trees and about one-tenth of all other trees or sprout groups were examined. If the trees examined were members of

sprout groups, the companion sprouts were also examined. A total of 1354 trees was examined on the four tracts.

Since only visible defects were noted, defect does not include interior stem defects such as heartrot which may be prevalent in stems originating as sprouts from stumps and in trees damaged by fire or by ice or snow that break their crowns. Further, the severity of the defect is not shown. In this analysis defects were grouped as follows: (1) scar or crown defect, both of which may precede incidence of decay in the stem, (2) stem tilted, crooked or spiral, (3) stem bowed or broken, and (4) stem forked, top dead or other.

Some of the many causes of the defects were wind, heavy loads of ice or snow, falling trees or large limbs, dying of large limbs, and possible past damage by fire causing deformity or breakage of crown or stem. Growth habit of trees in sprout groups is a possible cause of tilt or crookedness of members and adjacent trees. Death of the chestnut created openings into which the crowns of nearby trees expanded unevenly in the competition for light. Dead tops were probably caused mainly by reduced vigor when trees could not obtain adequate moisture and light.

Defects were present in 41 per cent of the 1354 trees examined on the four tracts (Table 14). They were significantly more prevalent in single trees, which had not been known members or survivors of a sprout group during the 30 years, than in the known members or survivors of sprout groups, which are called sprouts here. Forty-seven per cent of the 776 single trees were defective whereas 34 per cent of the sprouts were in similar condition. Incidence of defect was least on Turkey Hill where 22 per cent were defective and most on Reeves and Cabin where 54 and 57 per cent had defects.

In the dominant and codominant trees, tilted, crooked, or spiral stems were the most numerous defects followed closely by scar or crown defect (Table 14). The former were more prevalent on Cox and Cabin and the latter on Turkey Hill and Reeves.

In comparing incidence of defect by crown class and size of trees, gray birch, blue beech, hophornbeam, dogwood, shadbush, witch-hazel, and chestnut were excluded because these small species rarely became dominant. Furthermore, fewer defects were noted on these than on the major species of comparable size. Incidence of defect was greatest in the dominant and codominant trees (51 per cent) and least in the small understory trees 0.5 to 1.5 inches d.b.h. (26 per cent). Forty-one per cent of the intermediate or suppressed trees more than 1.5 inches d.b.h. had defects. Among the smaller understory trees, fewer of the stems were tilted, crooked or spiral, and fewer scars or crown defects were noted than among the larger trees, but more of these small trees had bowed or broken stems. Tilted, crooked, or spiral stems were the most frequently encountered defects in the minor species.

Fifteen of the more abundant major species were compared. All were nearly equally defective with the exception of beech where only one of the twenty-four examined were defective. Except red maple and white oak, the dominant and codominant trees of these 15 species had more defects than intermediate or suppressed trees.

Summarizing, defects were frequent with 41 per cent of the trees being defective. Frequency varied between the tracts of woodland, and the larger trees were more defective than the smaller. Most major tree species were nearly equally susceptible, and tilted, crooked, or spiral stems and scar or crown defect were most frequently noted. Evidently trees originating from seedlings were as susceptible to the defects noted as trees from sprouts.

Table 14. Defects (number of trees with defect per 100 trees), all tracts, 1957

	Number trees examined		Scar or crown defect		Stem tilted, crooked or spiral		Stem bowed or broken		Stem forked, top dead or other		All defects		
	Single stems	Sprouts	Single stems	Sprouts	Single stems	Sprouts	Single stems	Sprouts	Single stems	Sprouts	Single stems	Sprouts	All
Major species, dominant and codominant trees													
All tracts	461	244	27	26	33	24	1	<1	6	6	55	43	51
Major species, intermediate and suppressed trees <1.5" d.b.h.													
All tracts	152	156	24	24	22	13	3	1	8	6	45	38	41
Major species, intermediate and suppressed trees 0.5"-1.5" d.b.h.													
All tracts	91	57	12	9	10	2	8	4	5	4	32	16	26
Minor species, dominant and codominant trees													
All tracts	1	2	0	50	0	0	0	0	0	0	0	50	33
Minor species, intermediate and suppressed trees <1.5" d.b.h													
All tracts	13	28	8	0	23	29	0	4	8	4	38	36	37
Minor species, intermediate and suppressed trees 0.5"-1.5" d.b.h.													
All tracts	58	90	2	1	12	2	0	4	0	2	12	10	11

CHARACTERISTICS OF EACH SPECIES

To bring each species into better focus their characteristics are discussed separately.

Red Maple. This species had the greatest abundance and most uniform distribution. One-fourth of the trees of the major species or 270 trees per acre in 1927 and 28 per cent or 146 trees per acre in 1957 were red maples. The proportion was similar on moist, medium moist and dry sites and on the different tracts. On muck, three-fifths of the trees were red maples.

The red maples were small, however; in 1927, 96 per cent, and in 1957, 86 per cent were less than 5.6 inches d.b.h. Less than 1 tree per acre or 1 per cent had attained sawtimber size in 1957.

In 1927, average basal area of red maple was the greatest of any species, 10 sq. ft. per acre or 14 per cent of the total, but although it increased to 11.5 sq. ft. per acre by 1957, it was then only 11 per cent of the total. Its greatest basal area was on the moist sites where it comprised one-fourth of the total in 1927 and one-fifth in 1957.

The average height of the dominant and codominant trees in 1957 excluding those on muck, was 63 feet, 5 less than the average for all species. The five trees measured on muck averaged only 47 feet.

This species was the most important in the canopy on the moist sites where 19 per cent of all dominant and codominant trees in 1927 and 22 per cent in 1957 were red maple. On less moist sites, it was less important; on the dry sites the proportion of red maple among the dominant and codominant trees decreased from 11 to less than 1 per cent in 30 years. More than half of the trees were known sprouts. The proportion decreased among the dominant and codominant trees but did not change among the intermediate or suppressed.

The average mortality was slightly less than the average for all major tree species; only 32 per cent of the red maples present in 1927 died in a decade and 43 per cent of the trees present in 1937 died in two decades. During the first decade 13 recruits per acre or 7 per cent of the number of red maples present in 1937 appeared. During the next two decades, 44 per acre or 30 per cent of the total number present in 1957 appeared. Many of these, of course, were present but smaller than 0.5 inch prior to 1937. Ingrowth increased during the 30 years on all soil moisture classes, especially on the dry sites where it rose from 11 trees per acre during the first decade to 63 during the next two decades and compromised fully 39 per cent of the trees present in 1957. The dominant and codominant trees of all species were less defective than those of most other species, but the intermediate or suppressed red maples were among the more defective species. The most frequent defects were scar or damaged crown and tilted or crooked stem.

Red maple was the most abundant and most uniformly distributed of any species and, since its rate of ingrowth was high, should continue to be. But because it has decreased in importance in the canopy, except on the moist sites, its role in the future seems largely as a subordinate or understory tree.

Sugar Maple. This species was most abundant on the moist sites, 75 trees per acre in 1927 and 72 in 1957. Although its numbers changed little, the proportion of sugar maples among the major species increased from 8 per cent in 1927 to 14 in 1957. It was markedly less abundant on drier sites.

In 1927, 96 per cent and in 1957, 93 per cent were less than 5.6 inches d.b.h. and by 1957 less than 1 tree per acre had attained sawtimber size. Its average basal area was low, 1.5 sq. ft. per acre in 1927 and 2 in 1957; the

greatest basal area occurred on the moist sites, 4 sq. ft. per acre in 1927 and 5 in 1957. There was a slight increase in the proportion of basal area of sugar maple on the moist and medium moist but no change on the dry sites. The average height of the dominant and codominant sugar maples in 1957 was 72 feet, 4 more than the average for all species. It was important in the canopy only on the moist sites where 3.5 per cent in 1927 and 4 percent in 1957 of the dominant and codominant trees were sugar maples.

The proportion of known sprouts on the dry sites increased during the 30 years until in 1957 they included two-thirds of the trees. The proportion of sprouts was much less on the moist and medium moist sites.

During the first decade its mortality was least of all species and only 18 per cent of those present in 1927 died. During the next two decades mortality was least except for scarlet oak and unimportant white birch and only 31 per cent of the trees present in 1937 died. Three new trees per acre or 9 per cent of the trees present in 1937 were recruited during the first decade and 12 trees or 34 per cent of those present in 1957 were recruited from 1937 to 1957. Dominant and codominant sugar maples were less defective than all other species, only 29 per cent defective in 1957; the intermediate and suppressed trees were less defective than those of most other species, only 21 per cent defective. The low rate of mortality and the increase of ingrowth, particularly on Turkey Hill following the 1938 hurricane, suggest that this species may increase in importance in the stands.

Red Oak. This species was abundant on all tracts and all soil moisture classes except muck. It was most abundant on the medium moist sites where there were 110 trees per acre in 1927 and 45 in 1957. This was 8 per cent of the total number of trees of the major species at both times. Although red oak was slightly less abundant on dry, and even less abundant on moist sites, even on the moist sites 70 trees per acre were present in 1927 and 38 in 1957.

In 1957 only 35 per cent of red oaks were less than 5.6 d.b.h. and 10 trees per acre or 23 per cent of the total number had attained sawtimber size. Eighty-six per cent of the trees were less than 5.6 inches d.b.h. in 1927. The average basal area of red oak became greater than any other species; from 8 sq. ft. per acre or 12 per cent of the total for all species in 1927 it grew to 20 sq. ft. per acre or 20 per cent in 1957. It was greatest on the medium moist sites. The average height of the dominant and codominant trees in 1957 was 70 feet, 2 feet greater than the average for all species. This species was the most important one in the canopy, and 13 per cent of all dominant and codominant trees in 1927 and 21 per cent in 1957 were red oaks. It was important in the canopy on all sites except muck and was most important on the medium moist sites. About two-thirds of the trees were known sprouts.

Average mortality during the first decade was the same as that for all major tree species, and 34 per cent of the red oaks present in 1927 died by 1937. It was less during the next two decades; 38 per cent of those present in 1937 died by 1957. Ingrowth was slight; only 5 recruits per acre during the first decade or 7 per cent of the red oaks present in 1937 and only 4 during the next two decades or 8 per cent of those present in 1957. Nearly two-thirds of the dominants and codominants were defective while only about one-fourth of the intermediate or suppressed trees were defective. The most frequent defects were tilted or crooked stem and scar or damaged crown. Red oak became increasingly important in the canopy during the 30 years, but the low rate of ingrowth may affect its importance in the future.

Black Oak. This species was most abundant on the dry sites with 94 trees per acre in 1927 and 39 in 1957. This was 8 percent of the total number of trees of the major tree species in 1927 and 7.4 per cent in 1957. The abundance decreased sharply on moist soil. In 1927, 86 per cent of the trees were less than 5.6 inches d.b.h., but in 1957 only 21 per cent were in that small size class. In 1957, 4 trees per acre or 27 per cent of those present were sawtimber size. The average basal area of black oak increased from 3 sq. ft. per acre or 4 per cent of the total for all species in 1927 to 9 sq. ft. per acre or 9 per cent in 1957, and its greatest basal area occurred on the dry sites, 18 sq. ft. per acre, in 1957. The average height of the dominant and codominant trees in 1957 was 69 feet, 1 foot greater than the average of all species. On the dry sites this species was the most important in the canopy; 13 per cent of all dominant and codominant trees in 1927 and 26 per cent in 1957 were black oaks. The proportion of known sprouts was low, about 15 per cent, and was only slightly greater among the intermediate and suppressed trees than among the dominants or codominants. Mortality was lower than the average of major tree species throughout the period; only 28 per cent died during the first and 35 per cent during the next two decades. Ingrowth was very poor; only 2 trees per acre were recruited during the first and 1 in the next two decades. This was 6 per cent of the trees present in 1927 and 4 per cent of those present in 1957. There was no ingrowth on muck or moist sites. Fully 48 per cent of the dominant and codominant trees and 37 per cent of the intermediate and suppressed trees were defective in 1957. The most frequent defects were tilted or crooked stem and scar or damaged crown. Although less abundant over the entire area, black oak has become the most important species in the canopy on the dry sites.

Scarlet Oak. Scarlet oak was most abundant on the dry sites where 41 per acre were present in 1927 and 23 in 1957 or 3.5 per cent of the total number of trees of the major tree species in 1927 and 4.3 per cent in 1957. It was less abundant on moist soil. In 1927, 67 per cent of the trees were less than 5.6 inches d.b.h., but in 1957 only 11 per cent were that small, and more than 3 trees per acre or 29 per cent of the scarlet oak had attained sawtimber size. The average basal area increased from 3 sq. ft. per acre in 1927 to 7 sq. ft. in 1957 or from 4 to 7 per cent of the total for all species. It was greatest on the dry sites where it increased from 4 sq. ft. per acre in 1927 to 10 in 1957. The average height of the dominant and codominant trees in 1957 was 70 feet, 2 feet greater than average for all species. Scarlet oaks attained greatest importance in the canopy on the dry sites where in 1927, 8 per cent and in 1957, 16 per cent were dominant and codominant trees. The proportion of known sprouts was low and decreased from 25 to 18 per cent during the three decades.

Mortality was low: 24 per cent of the trees present in 1927 died during the first and 31 per cent of those present in 1937 died during the last two decades. The only ingrowth of this species was less than 1 tree per acre on Cabin during the first decade and 3 trees per acre on Turkey Hill during the last two decades. Only 1 of the 4 intermediate and suppressed trees examined in 1957 was defective, whereas 40 per cent of the 68 dominant and codominant trees were defective. The most frequent defects were scar or damaged crown and tilted or crooked stem. Although scarlet oak increased in importance in the canopy during the 30 years, the slight ingrowth provide few replacements for the future.

White Oak. This species was most abundant on the dry sites where 189 trees per acre were present in 1927 and 47 in 1957 or 16 per cent of the total number

of trees of the major species in 1927 and 9 per cent in 1957. White oak was less abundant on the medium moist sites and much less abundant on the moist sites. During the 30 years, the number of trees decreased greatly on all sites.

Ninety-three per cent of the trees in 1927 and 44 per cent in 1957 were less than 5.6 inches d.b.h. and only little more than 2 trees per acre attained sawtimber size by 1957.

In 1927 the average basal area was 6 sq. ft. per acre or 9 per cent of the total for all species, and it increased little to 8 sq. ft. per acre or 8 per cent in 1957. The greatest basal area occurred on the dry sites, but it decreased from 15 to 14 per cent of the total during 30 years.

The average height of the dominant and codominant trees in 1957 was 65 feet, 3 feet less than the average for all species. The average proportion of dominant and codominant trees of white oak in the canopy remained near 8 per cent throughout the 30 years, whereas the proportion increased for all other oaks. On the dry sites, where it was most abundant, it increased from 12 per cent in 1927 to 18 in 1937, but then decreased to 14 per cent in 1957. The proportion did increase, however, on hurricane-disturbed Turkey Hill. The proportion of known sprouts was only one-fourth of the dominant and codominant and one-fifth of the intermediate or suppressed trees.

Mortality was high; 42 per cent of the trees present in 1927 died during the first decade and 65 per cent of those present in 1937 died during the next two decades. Ingrowth was slight; 5 trees per acre or 6 per cent of those present in 1937 were recruited during the first decade, and 3 trees or 11 per cent of the number present in 1957 were recruited during the next two decades. Although 41 per cent of the dominant and codominant trees were defective, relatively fewer than most oak species, fully 61 per cent of intermediate or suppressed trees were defective, more than any other oak. The most frequent defects were tilted or crooked stem and scar or crown defect.

The lower average height and the decreases noted during the last two decades indicate white oak is becoming less important in both canopy and understory.

Chestnut Oak. Chestnut oak was the most unevenly distributed oak. In 1957 it was abundant on Turkey Hill, 35 trees per acre, and on Cabin, 46 trees per acre, but scarce on Cox and Reeves, less than 2 trees per acre. The proportion of chestnut oak increased on all tracts except Reeves where it decreased slightly. Chestnut oak was most abundant on the medium moist sites where 36 trees per acre were present in 1927 and 23 in 1957; this was 3.3 per cent of the total number of trees of the major tree species in 1927 and 4.5 per cent in 1957. Chestnut oak was less abundant on the dry sites and still less abundant on the moist. In 1927, 71 per cent, and in 1957, 41 per cent of the trees were less than 5.6 inches d.b.h. By 1957, 3.7 trees per acre attained sawtimber size.

Basal area of chestnut oak differed greatly among tracts; in both 1927 and 1957 Cox and Reeves had less than 1 sq. ft. per acre while Cabin had 15 sq. ft. per acre in 1927 and 28 in 1957. The greatest basal area occurred on the medium moist sites. The average height of the dominant and codominant trees in 1957 was 68 feet, the same as for all species. Chestnut oak became increasingly important in the canopy on tracts where it abounded and on all soil moisture classes except muck. It attained greatest importance in the canopy on the medium moist sites, where 6 per cent in 1927 and 10 per cent in 1957 of the dominant and codominant trees were chestnut oaks. One-third of the trees were known sprouts; the proportion was slightly greater among the intermediate and suppressed trees than among the dominants or codominants.

Mortality of chestnut oak was similar to but ingrowth was greater than, red, black, and scarlet oaks. Twenty-nine per cent of the trees present in 1927 died during the first decade and 41 per cent of those present in 1937 by 1957. Recruits averaged 3 trees per acre during the first decade and 5 in the next two decades, a greater proportion of the trees present in both 1937 and 1957 than in the other oaks. Ingrowth of chestnut oak was much greater on Turkey Hill than on the other tracts; 7 recruits per acre appeared on the medium moist and dry sites in the first decade and 23 in the next two decades. Frequency of defect in the dominant and codominant trees of this species was high, 58 per cent, while only 37 per cent of the intermediate or suppressed trees were defective. The most frequent defects were tilted or crooked stem followed by scar or damaged crown.

Chestnut oak was the most variable in abundance of any of the oaks, with seed source seemingly the important factor.

Yellow Birch. Yellow birch was most abundant on moist sites. In 1927 there were 163 trees per acre and in 1957, 110, or 18 per cent of the total for all major tree species in 1927 and 22 per cent in 1957. Only red maple was more abundant. The proportion decreased greatly on the dry sites where less than 1 per cent of the trees were yellow birch in 1927 and 1957. In 1927, 91 per cent, and in 1957, 80 per cent of the yellow birches were less than 5.6 inches d.b.h.; less than 2 per acre attained sawtimber size by 1957.

Basal area was greatest on moist sites; 13 sq. ft. per acre or 15 per cent of the total for all species in 1927 and 18 sq. ft. per acre or 17 per cent in 1957. Basal area decreased greatly with increasing dryness, and on the dry sites it was less than 1 sq. ft. per acre throughout the three decades. The average height of the dominant and codominant yellow birch in 1957 was 61 feet, 7 feet less than the average for all species. On moist sites this species comprised 9 per cent of the dominant and codominant trees in 1927 and 16 per cent in 1957. The proportion decreased sharply with decrease in soil moisture, and none were in the canopy on the dry sites in 1957. The proportion of known sprouts was high, more than half, and it was slightly greater among the intermediate and suppressed trees than among the dominant or codominant trees.

Mortality was less than the average for major tree species; 29 per cent of the trees present in 1927 died by 1937 and 41 per cent of those present in 1937 died by 1957. Ingrowth on the moist sites was rapid, 19 recruits per acre during the first decade and 21 in the next two. It increased most on medium moist sites, from 6 new recruits per acre during the first decade to 22 in the next two, and was least on the dry sites where only 4 recruits per acre appeared during the 30 years. On muck 18 per acre were recruited after the 1938 hurricane. Forty-five per cent of the dominant and codominant and 35 per cent of the intermediate or suppressed trees were defective in 1957. The most frequent defects were scar or damaged crown; tilted or crooked stem and forked stem or dead top were other important but less frequent defects.

On the moist sites of Turkey Hill 10 trees per acre grew from intermediate or suppressed in 1927 to dominant or codominant trees in 1957, due probably to opening of the canopy during the 1938 hurricane. Yellow birch has become an increasingly important component on the moist sites, and evidently will continue to do so.

Black Birch. This species was among the most abundant on all tracts during the 30 years. It was most abundant on the dry sites, where 168 trees per acre were present in 1927 and 114 in 1957. This was 14 per cent of the total number of

trees of all major tree species in 1927 and 21 in 1957. Abundance decreased as soil moisture increased, and on the moist sites there were 44 trees per acre in 1927 and 34 in 1957 or 5 per cent of the total for all major tree species in 1927 and 7 per cent in 1957. Ninety per cent of the trees in 1927 and 70 per cent in 1957 were less than 5.6 inches d.b.h.; 3.8 trees per acre attained sawtimber size in 1957.

The basal area was similar on all soil moisture classes except muck. The average was 9 sq. ft. per acre in 1927 and 13 in 1957 or 13 per cent of the total for all species in both 1927 and 1957. The average height of the dominant and codominant trees in 1957 was 67 feet, one foot less than for all species. After red oak this was the most important species in the canopy on the medium moist sites; 13 per cent of the dominant and codominant trees in 1927 and 15 in 1957 were black birch. It was also important on the moist sites where the percentage increased from 4 to 12 during the 30 years. On the dry sites, however, it decreased from 17 to 6 per cent. The proportion of known sprouts decreased from 38 per cent in 1927 to 27 in 1957, and it was only slightly greater among the intermediate and suppressed trees than among the dominant or codominant.

Mortality was less than the average for all major species; 27 per cent of the trees present in 1927 died by 1937, and 38 per cent of those present in 1937 died by 1957. Ingrowth was greatest on the dry sites, where 13 per acre were recruited in the first and 32 in the next two decades. Except for muck, recruits were least on the moist sites, only 1 and 10 per acre in the same periods. More than half of the trees were defective. The most frequent defects were scar or damagd crown and tilted or crooked stem. Dead top probably caused by nectria canker was another, less frequent defect. More trees of this species than any other grew from intermediate or suppressed in 1927 to dominant or codominant trees in 1957; 8.3 trees per acre on hurricane-disturbed Turkey Hill and 1.5 on the other tracts. Although this species was most abundant on dry sites, its importance in the canopy decreased greatly there, but it became more important on the moist and medium moist sites.

White Ash. In 1927 this species was abundant on all except the dry sites. White ash on muck more than doubled from 37 per acre in 1927 to 80 in 1957. On other sites the number decreased during the three decades, and the decrease was progressively greater as the site was drier. On moist sites, where it was most abundant, there were 63 ash per acre in 1927 and 28 in 1957 or 7 percent of the total for all major tree species in 1927 and 5 per cent in 1957. On dry sites, where it was least abundant, there were 24 trees per acre in 1927 and 5 in 1957 or 2 per cent of the total number for all major tree species in 1927 and less than 1 in 1957. Ninety-six per cent of the white ash in 1927 and 72 per cent in 1957 were less than 5.6 inches d.b.h., and less than one per acre attained sawtimber size by 1957.

The greatest basal area occurred on the moist sites; 4 sq. ft. per acre or 4 per cent of the total for all species in 1927 and 5 sq. ft. per acre or 5 per cent of the total in 1957. It decreased from 4 per cent in 1927 to 2 in 1957 on the medium moist and from 2 per cent in 1927 to less than 1 in 1957 on the dry sites. The average height of the dominant and codominant trees in 1957 was 64 feet, 4 feet less than the average for all species. White ash was most important as a component of the canopy on the moist sites with 6 per cent of the dominant and codominant trees in 1937 and 7 per cent in 1957. The proportion decreased with decreasing soil moisture and also with time on the drier sites. On the dry sites it decreased from 2 per cent in 1927 to none in 1957. The percentage of known sprouts decreased from 51 to 30 among the dominants and

codominants during the three decades, but increased from 35 to 40 per cent among the intermediate or suppressed trees.

Mortality of this species was greater than in most important major tree species during all three decades. Compared to the moist and medium moist sites, mortality on the dry was lower during the first decade, but much higher in the next two decades when four-fifths died on the dry sites. Ingrowth, 2 recruits per acre, was less than the average for all major species in the first decade and about average in the next two decades with 5 per acre. Nearly two-thirds of the dominant and codominant trees were defective compared to about one-quarter of the intermediate or suppressed. The most frequent defects were scar or damaged crown and tilted or crooked stem. White ash was an important component of the stands on the muck and moist sites and became more important there during the three decades, but it was less important on the drier sites and decreased in importance there.

Pignut Hickory. This was the most abundant hickory. It was most numerous on the dry sites with 101 trees per acre in 1927 and 20 in 1957 or 9 per cent of the total trees of the major species in 1927 and 4 per cent in 1957. Its abundance decreased with increasing soil moisture, and on the moist sites there were 11 trees per acre in 1927 and 3 in 1957 or 1 per cent or less of the total for all major tree species in both 1927 and 1957. The proportion of pignut hickory decreased on all sites. Ninety-seven per cent of the trees in 1927 and 73 per cent in 1957 were less than 5.6 inches d.b.h., and less than 1 tree per acre attained sawtimber size by 1957.

Its greatest basal area occurred on the dry sites; 2.5 sq. ft. per acre in 1927 and 2.6 in 1957 which was 5 per cent of the total for all species in 1927 and 3 per cent in 1957. Basal area decreased with increase in soil moisture, and on the moist sites there was less than 1 sq. ft. per acre throughout the three decades. The average height of the dominant and codominant trees in 1957 was 68 feet, the same as for all species. Pignut hickory was most important in the canopy on the dry sites where it comprised 4 per cent of the dominant and codominant trees in 1927 and 5 in 1957. The proportion in the canopy decreased with increasing soil moisture and on the moist sites was 1 per cent or less in both 1927 and 1957. Only about 10 per cent of the trees in 1927 and 16 per cent in 1957 were known sprouts and there was little difference between canopy and understory.

Mortality of pignut hickory was greater than the average for major species; nearly half of those present in 1927 died by 1937 and more than half of those present in 1937 died by 1957. Although ingrowth was greater for this species than for other hickories, it was only 2 per acre during the first and 2 during the next two decades. Six of the 16 dominant and codominant trees and 1 of the 3 intermediate and suppressed ones sampled were defective.

High mortality and poor ingrowth indicates decreasing importance in the stands, even on the dry sites where it was most abundant.

Shagbark Hickory. This species was one of the less abundant, and although it grew on all sites except muck, it occurred less frequently on dry than on the moist sites. The average number of trees per acre for all sites was 10 in 1927 and 5 in 1957, less than 1 per cent of the major species in both 1927 and 1957. Eighty-eight per cent of the trees in 1927 and 55 in 1957 were less than 5.6 inches d.b.h., and none attained sawtimber size.

Shagbark hickory gained in percentage of total basal area and only on the moist sites, and, even there, it was only about 1 per cent. Basal area, as well as

number, of shagbark hickories was much less on Cabin than on the other tracts. Average height of the dominant and codominant trees in 1957 was 70 feet, 2 feet greater than that for all species. Shagbark hickory contributed most to the canopy on the moist sites with 1.1 per cent of all dominant and codominant trees in 1927 and 2.5 per cent in 1957. One-third of the trees were known sprouts, and the proportion was slightly greater among the dominant and codominant trees than among the intermediate or suppressed. It changed little during the 30 years.

Mortality of shagbark was the lowest of the hickories and less than the average for all major tree species; 28 per cent of the trees present in 1927 died by 1937 and 31 per cent of those present in 1937 died by 1957. During the last two decades, mortality for this species was much greater on the drier sites than elsewhere. No recruits appeared during the first and less than 1 per arce during the next two decades. Four of the 9 dominant and codominant and 2 of the 6 intermediate or suppressed trees examined were defective in 1957.

Shagbark hickory was unimportant in the stands and because there were few trees and little ingrowth, it will likely continue so.

Mockernut Hickory. This species was most abundant on dry sites; 22 trees per acre in 1927 and 8 in 1957 or 1.9 per cent of total number of trees of the major species in 1927 and 1.6 in 1957. It was absent on moist sites in 1957. Ninety-six per cent of the trees in 1927 and 74 per cent in 1957 were less than 5.6 inches d.b.h., and less than 1 tree per acre attained sawtimber size by 1957.

The basal area was 0.7 sq. ft. per acre in 1927 and 1 in 1957 on both medium moist and dry sites. Average height of dominant and codominant trees in 1957 was 66 feet, 2 feet less than that for all species. This hickory was most abundant in the canopy of the medium moist sites with 1.6 per cent of all dominant and codominant trees in 1927 and 1.8 per cent in 1957. Only about 10 per cent of the trees were known sprouts, and the proportion was only slightly greater among the intermediate and suppressed trees than among the dominant or codominant.

Mortality was less than the average for all major species; 30 per cent of the trees present in 1927 died by 1937 and 47 per cent of those present in 1937 died by 1957. Less than 1 tree per acre was recruited during the first and only 1 during the next two decades, and all were recruited on the medium moist sites. Three of the 7 dominant and codominant trees examined were defective in 1957.

Mockernut hickory was unimportant, and with few trees and little ingrowth it will continue so.

Beech. Except for the unimportant white pine and chestnut, this was the only species whose numbers increased from 1927 to 1957. Beech increased in numbers on all tracts except Turkey Hill. It was most abundant on the dry sites, increasing from 25 per acre in 1927 to 28 in 1957, but it increased on the moist and medium moist sites as well. The average number on all sites increased from 1.3 per cent of the total for all major species in 1927 to 3.4 per cent in 1957.

Ninety-eight per cent in 1927 and 97 per cent in 1957 of the trees were less than 5.6 inches d.b.h., and less than 1 tree per acre attained sawtimber size by 1957.

Because the trees were nearly all small, the average basal area of this species was slight, 0.4 sq. ft. per acre in 1927 and 0.9 in 1957 or less than 1 per cent of the total for all species in both 1927 and 1957. Its greatest basal area per acre occurred on the dry sites. The average height of the three dominant and codominant trees measured in 1957 was 68 feet, the same as the average for all

species. Beech was not important in the canopy during the three decades because the number of dominant or codominant trees was less than one per acre. Sixty per cent of all beech were known sprouts in 1927 and 48 per cent in 1957.

The average mortality was less than that for any major tree species except sugar maple during the first decade; only 22 per cent of the beech present in 1927 died by 1937 and 45 per cent of the trees present in 1937 died by 1957. During the first decade ingrowth was 18 per cent of the trees present in 1937, and during the next two decades it was 58 per cent of those present in 1957. Proportionally, ingrowth of beech was greater than nearly all other major tree species and greater than any of the important ones. The number of recruits was greatest on the dry sites during the first decade and on the moist sites during the next two decades. None of the 21 intermediate or suppressed trees and only 1 of the 3 dominant and codominant trees examined were defective. Although beech has not been important in the stands to date, its wide dispersal, increasing numbers and tolerance of shade suggest that it may become important.

Tuliptree. Tuliptree was most abundant on the medium moist sites; 14 trees per acre in 1927 and 7 in 1957 or 1.3 per cent of the total number of trees of the major species in both 1927 and 1957. It was nearly as abundant on the moist, but much scarcer on the dry sites. Sixty-nine per cent of the trees in 1927 and 20 per cent in 1957 were less than 5.6 inches d.b.h.; 2 trees per acre attained sawtimber size by 1957.

Basal area of tuliptree was greatest on the moist and medium moist sites, about 2 sq. ft. per acre in 1927 and 4 in 1957 on both medium moist and moist sites. It increased from about 3 per cent of total basal are in 1927 to 4 in 1957. On the dry sites basal area was less than 1 sq. ft. per acre during the 30 years. The average height of the dominant and codominant trees in 1957 was 75 feet, 7 feet greater than the average for all species. This species was most important in the canopy on the medium moist sites where 3 per cent of all dominant and codominant trees in 1927 and 4 in 1957 were tuliptree. It was slightly less abundant in the canopy on the moist and much less on the dry sites. The slight increase of tuliptree in the canopy was made only in the first decade. Slightly more than one-third of the trees were known sprouts; the proportion decreased among the dominant and codominant but increased among the intermediate or suppressed trees during the 30 years.

Mortality was less than the average for all major tree species during the first decade; 23 per cent of the trees present in 1927 died by 1937. During the next two decades it was similar to the average and 45 per cent of those present in 1937 died by 1957. Ingrowth was very poor, less than 1 recruit per acre in the first and only 1 in the next two decades. Nearly half of the dominants and codominants were defective, while only one-fifth of the intermediate or suppressed trees had defects. The most frequent defects were scar or damaged crown. Relatively few trees had tilted or crooked stem.

Although dominant tuliptrees were among the tallest of the trees this intolerant species was not abundant. The failure to increase in the canopy during the last two decades does not indicate a good future for tuliptree in these unmanaged stands.

Sassafras. Only 14 trees per acre were present in 1927 and 7 in 1957. They were evenly distributed on all sites except muck. Most were sapling size with basal area less than 1 sq. ft. per acre in both 1927 and 1957. Mortality was great, but ingrowth increased from less than 1 per acre in the first to 4 in the next two decades. Most recruits were probably root suckers and, hence, were classified as "not sprouts."

Aspen. Aspen was most numerous on Cox and occurred mainly with other pioneer species on that part of the tract which had apparently been cleared previously. It was present on only three tracts in 1927 and only on Cox in 1957. It was most abundant on Cox in 1927, averaging 37 trees per acre with a basal area of 5 sq. ft. per acre. Aspen occurred on all sites except muck, but was most abundant and had the greatest basal area on the moist sites. In 1937 one-tenth of all dominant and codominant trees on Cox were aspen, but its importance declined sharply in the next 20 years.

Tupelo. This species was not abundant and occurred most frequently on the moist sites where there were 19 trees per acre in 1927 and 11 in 1957. Most were sapling size, and none attained sawtimber size.

Elm. The few elm occurred mostly on the muck and moist sites. Its abundance decreased during the 30 years, and only one atttained sawtimber size by 1957.

Black Cherry. On Cox tract, part of which had apparently been cleared previously, there were 32 cherry per acre in 1927. Only one tree remained on the four tracts in 1957. Cherry occurred, however, on all sites except muck in 1927 and was most abundant on the moist sites. Very few were known sprouts, and most probably originated as seedlings along with other pioneer species prior to 1927.

Bitternut Hickory. This was the least abundant hickory and occurred only occasionally on the moist and medium moist sites of Cox and Cabin. On the medium moist sites, the 3 trees per acre in 1927 decreased to less than 1 in 1957.

Butternut. In 1927 there was an average of little more than 4 butternuts per acre on the four tracts. They occurred on all sites except muck and were most frequent on dry sites. Butternut was the only species to disappear by 1957.

Basswood. Basswood was found only on Cox and Reeves where there were about 5 trees per acre in 1927 and 1 in 1957. All occurred on moist and medium moist sites. One tree attained sawtimber size by 1957.

White Birch. This unimportant species had only 1 to 2 trees per acre present on Turkey Hill and Cabin tracts in both 1927 and 1957. It was restricted to the medium moist sites.

Black Ash. This unimportant species occurred mostly on muck on Turkey Hill where there were 6 trees per acre in 1927 and 12 in 1957. It was absent from the dry sites.

Black Locust. Black locust occurred only on Reeves on the dry sites where there were 4 trees per acre in 1927 and 1 in 1957.

White Pine. Conifers were unimportant on all tracts. Less than 1 white pine per acre was present on three tracts in both 1927 and 1957. On Cabin the average was 0.4 tree per acre in 1927 and 2.7 in 1957.

Hemlock. Hemlock was present only on Turkey Hill and Cox with less than 1 tree per acre present on each in both 1927 and 1957.

Red Cedar. Red cedar, a pioneer in old fields, was present on Turkey Hill and Cox tracts only. It was most abundant on Turkey Hill where 12 trees per acre were present in 1927 and less than 1 in 1957.

Gray Birch. Fully 166 trees per acre of this pioneer species grew on Cox in 1927. It was most abundant on that part of the tract which had apparently been cleared in the past. It decreased greatly in abundance, and by 1957 only 1 remained. On the other tracts it was much less abundant in 1927 and absent in 1957. Gray birch was absent from muck, but was evenly distributed among the other three soil moisture classes. Few grew larger than sapling size, and about two-thirds were known sprouts.

Its greatest basal area was the more than 6 sq. ft. per acre or 9 per cent of the total for all species on Cox in 1927. It was important in the canopy on Cox in 1927 when nearly one-fourth of the dominant and codominant trees were gray birch. As expected in the succession of species, gray birch had practically disappeared from the stands.

Blue Beech. Blue beech was by far the most abundant of the minor species on Cox in 1927 when 433 trees per acre were present. It declined, however, to 73 in 1957. It was most abundant on that part of the tract which had apparently been cleared. On the other tracts it was much less abundant. Although blue beech occurred on all soil moisture classes it was most abundant on moist sites. All were small and none grew larger than sapling size during the 30 years. Two-thirds of the trees were known sprouts. On Cox, where blue beech was most abundant, the basal area was nearly 4 sq. ft. per acre in 1927, but this decreased to 1.2 sq. ft. per acre in 1957. Although this species had great mortality during the 30 years the increased ingrowth has lessened the decrease.

Witch-Hazel. This abundant minor species was evenly distributed over the tracts, but was most abundant on the moist sites. The average number per acre decreased from 120 in 1927 to 85 in 1957. As a percentage of the total number of minor species, however, it increased from 25 in 1927 to 39 in 1957, and increases occurred on all soil moisture classes. None were larger than sapling size, and more than 90 per cent were less than 1.6 inches d.b.h. in both 1927 and 1957. These small trees contributed less than 1 sq. ft. per acre to the total basal area for all species. More than 80 per cent were known sprouts, frequently in groups of several stems. Mortality was great, but since ingrowth was rapid, witch-hazel remained abundant.

Dogwood. Dogwood was abundant on the medium moist and dry sites, less abundant on the moist and absent on muck. On the medium moist sites, where it was most abundant, there were 51 trees per acre in 1927 and 37 in 1957. Only occasionally did any grow larger than sapling size, and the basal area was less than 1 sq. ft. per acre in both 1927 and 1957. About half were known sprouts. Due to increased ingrowth and moderate mortality during the 30 years, this species continues to be well represented in the understory.

Hophornbeam. Although hophornbeam was not abundant, it was evenly distributed on three soil moisture classes, but was absent from muck. Hophornbeam was most abundant on the medium moist sites in 1927, 40 trees per acre, but in 1957 it was most abundant on the moist sites, 28 trees per acre. It rarely grew larger than sapling size, and the total basal area was less than 1 sq. ft. per acre in both 1927 and 1957. Less than half were known sprouts. Although mortality

was high, this species continued to be well represented in the understory due to increased ingrowth during the 30 years.

Shadbush. The beautiful shadbush was abundant in 1927, when an average of 18 trees per acre grew on the four tracts. Rapid mortality, particularly during the last two decades, and little ingrowth decreased shadbush to little more than 2 per acre in 1957. It was least abundant on muck, but evenly represented on the other moisture classes. Only one tree grew larger than a sapling, and it died. Two-thirds of the trees were certainly sprouts.

Chestnut. Sprouts of chestnut continue to appear on the tracts, but are blighted before they grow larger than saplings. It was most abundant on the dry and medium moist sites. Due to sprouting, chestnut continues abundant in the understory; an average of 36 sprouts per acre was present on the four tracts in 1957.

SOME EFFECTS OF FIRE

In 1932 a forest fire burned about 40 per cent of the Turkey Hill tract including 1.6 acres of the sample area. The intensity of burning varied in severity and increased generally with decrease in soil moisture on the tract. Thirty years after the fire, humus thickness was similar to that on the unburned area.

To determine the effects of fire, the burned area was compared with the unburned area of Turkey Hill. Comparisons in number of trees, basal area, and ingrowth are shown in Table 15.

The number of trees per acre of the major species on the burned area was reduced from 793 in 1927 to 170 in 1932, but vigorous ingrowth following the fire increased it to 1,323 by 1957. In 1927 there were 305 trees per acre of the minor species, excluding witch-hazel, but none following the fire. However, by 1957 there were 296 per acre present.

Changes in proportion of some species during the 30 years differed on the burned area from that on the unburned. Red oak, scarlet oak, black birch, and tuliptree increased on the burned while decreasing on the unburned. Sugar maple decreased on the burned area while increasing on the unburned. White ash decreased more on the burned than the unburned area.

On the burned area basal area of all species was reduced from 80 sq. ft. per acre in 1927 to 50 in 1932, but it increased to 82 by 1957. On the unburned area basal area was 72 sq. ft. per acre in 1927, 85 in 1937 and 93 in 1957. Thus, in terms of basal area, recovery from the fire has been rapid. For most species there were no great differences between burned and unburned areas in proportion of total basal area between 1927 and 1957. Among the more important differences chestnut oak and black birch increased on the burned area but decreased slightly on the unburned area. Sugar maple, black oak, yellow birch, white ash, and pignut hickory decreased slightly on the burned area but increased slightly on the unburned area. However, since the greater basal area of the larger surviving trees tends to overshadow that of the numerous smaller ingrowth trees, basal area would not seem to be a good indicator of change in species composition in burned areas such as this.

Comparison of ingrowth from 1932 to 1957 on the burned area with that on the unburned area from 1937 to 1957 does indicate some change in species composition, although this may be only temporary. Among the major species, oak comprised 34 per cent of the ingrowth on the burned compared to 22 per cent on the unburned area. Other important changes were the greater ingrowth by black birch, pignut hickory, and tuliptree and less ingrowth of sugar and red maple, yellow birch, and white ash on the burned than the unburned area.

Table 15. Comparison of burned and unburned areas of Turkey Hill

		Number trees/acre				Basal area (sq. ft./acre)				Ingrowth (No. trees/acre)	
		1927	1932	1937	1957	1927	1932	1937	1957	1932 to 1957	1937 to 1957
Major species	Burned	793	170	. ...	1323	74	50	.....	79	1235	.....
Major species	Unburned	774	.....	631	556	66	.....	79	89	.....	189
Minor species[a]	Burned	305	0	.....	296	6	0	.....	3	657	.....
Minor species[a]	Unburned	332	.....	197	173	6	.....	6	4	.....	175

	Burned		Unburned		Burned		Unburned		Burned	Unburned
	1927	1957	1927	1957	1927	1957	1927	1957	1932 to 1957	1937 to 1957
Major species	*Per cent of major species*				*Per cent of all species*				*Per cent of major species*	
Sugar Maple	9.7	9.3	5.6	13.5	7.9	6.9	1.7	2.5	8.8	18.9
Red Maple	9.8	14.2	16.6	21.1	5.2	5.2	19.4	13.6	14.4	28.6
Red Oak	7.9	9.6	11.6	9.2	6.1	11.0	5.0	11.3	9.7	6.6
Black Oak	3.3	3.0	2.2	1.7	5.5	5.0	2.8	6.1	2.9	.4
Scarlet Oak	2.5	3.6	2.4	1.6	2.5	2.8	3.3	2.7	3.8	1.5
White Oak	9.0	6.6	6.0	5.1	9.5	12.7	6.3	7.8	6.3	5.1
Chestnut Oak	8.5	11.5	5.4	6.3	10.2	13.0	6.5	6.3	10.9	8.8
Yellow Birch	6.7	4.1	16.5	15.7	7.9	5.8	16.3	16.6	3.6	10.3
Black Birch	10.2	17.6	9.3	9.9	16.9	19.4	14.7	14.2	17.7	5.1
White Ash	9.8	1.7	7.6	4.2	5.2	2.2	2.9	3.1	1.6	4.0
Pignut Hickory	11.8	7.2	4.0	2.6	6.0	3.0	3.0	3.1	7.5	2.2
Shagbark Hickory	.9	.3	1.0	.7	.8	.7	1.2	.8	.2	0
Tuliptree	1.0	3.8	1.4	.9	2.2	5.8	2.5	4.2	4.0	.2
Beech	1.3	1.7	3.0	2.8	.4	.3	.4	.4	1.8	2.9
Black Cherry	.4	1.0	.2	0	.1	.4	<.1	0	1.0	0
Sassafras	1.9	2.7	2.9	2.0	.4	.4	.9	1.0	2.9	3.1
All other major species	5.3	2.1	4.3	2.7	5.3	1.3	4.2	2.3	2.9	2.3
Minor species	*Per cent of minor species*				*Per cent of all species*				*Per cent of minor species*	
Gray Birch	5.2	1.1	9.9	0	1.2	.1	2.8	0	.5	0
Blue Beech	34.0	24.6	47.0	50.2	2.5	.5	2.6	1.5	11.1	29.4
Witch-Hazel	.....	.....	.....	.....	.....	.....	.....	.....	54.8	47.9
Dogwood	44.9	61.1	28.6	39.5	3.1	3.0	2.2	2.0	27.5	16.1
Hophornbeam	15.7	12.1	12.1	4.8	1.1	.5	1.1	.3	5.5	1.4
All other minor species	.2	1.1	2.4	5.5	<.1	<.1	.1	.1	.6	5.2

[a]Witch-hazel excluded

Mortality from fire was greatest among the smaller trees. Among the major species there were 345 small saplings per acre in 1927, only 17 in 1932, but 704 in 1957. There were 329 large saplings per acre in 1927, 76 in 1932 and 545 in 1957. Mortality from fire was much less in the larger size classes.

In 1957 the average height of the dominant and codominant trees was 46 feet on the burned compared to 61 feet on the unburned area. Average height on the burned area included older trees which survived the fire and the much younger dominants and codominants in the groups of new recruits.

The proportion of single trees, as opposed to known sprouts, increased from 51 per cent in 1927 to 58 in 1957 on the burned area, while it remained 63 to 62 per cent on the unburned. On the burned area the greatest increase in single trees occurred on the dry sites, from 39 to 50 per cent. On the medium moist sites increase was less, from 53 to 60, and there was no change on the moist sites where 61 per cent were single trees.

As on the unburned part of Turkey Hill large trees were more defective than the small and single trees were also more defective than known sprouts. The greatest incidence of defect was among the dominant and codominant single trees for scar or crown defect and tilted, crooked or spiral stems. On the burned area 41 per cent of the 76 dominant and codominant single trees had scar or crown defects while only 20 per cent of the 120 dominant and codominant trees on the unburned area had similar defects. If, on the burned area, ingrowth since the fire was excluded, the incidence of scar defect would be even higher on trees surviving the fire. Also, 26 per cent of the trees on the burned area had tilted, crooked or spiral stems while only 8 per cent on the unburned area had similar defects. The smaller intermediate and suppressed trees on the burned area were slightly more defective than those on the unburned area.

Although fire caused much mortality, recovery has been rapid due to abundant ingrowth of new recruits. This is reflected in the increase in basal area from 50 sq. ft. per acre in 1932 after the fire to 82 in 1957. This is nearly 90 per cent of the basal area on the unburned area in 1957.

Although the fire represented a severe disturbance, it did not greatly change the species composition. This is not surprising because fire quite likely caused similar disturbances in the past on this area. Consequently, any great change in species composition due to fire would have been effected previously. Nevertheless, there were some noteworthy changes in species composition.

The most striking change was the increase in proportion of oak in the ingrowth. This supports the notion that fire favors oaks at the expense of other species. The increased ingrowth of the light-seeded black birch would be expected after fire. Apparently, intolerant tuliptree also responded to the new openings and exposed seed beds. However, the increase of these intolerant species may only be temporary if they are unable to compete with the vigorous oaks in the dense new stands.

Fire delayed the development of this stand by at least two decades. In addition to the loss of basal area there was increased incidence of defect, particularly scarring. Although new openings were made and seedbeds exposed, ingrowth after fire was largely oak. It seems unlikely that fire would be an effective tool for reducing the predominance of oak unless protected islands of seed trees of more favored species remain.

SUMMARY AND CONCLUSIONS

The natural changes during 30 years in four tracts of mixed hardwoods typical of many Connecticut woodlands were determined.

Before 1927 the tracts were repeatedly cut over for wood. Evidently some parts of each were even cleared for pasture or crops, but the boundaries cannot now be accurately determined. This is typical of much Connecticut woodland. As time passes, species succeed one another on the previously cleared lands. The species that stand upon the land in any year as well as the speed of the successional procession depend upon how long ago the erstwhile farm was abandoned. In 1927 our tracts were wooded and the procession had slowed to a speed scarcely perceptible in a year or even two. Although the first 30 years of this study permit little of this slow portion of the procession to pass, certain changes have been affected in nature, are discernible, and adumbrate others yet to be seen.

Mortality generally decreased, while ingrowth increased during the 30 years. This is not surprising since many trees were present in 1927 when the stands were young. During the first decade many died in the dense population, and then fewer died in the less dense population of the next two decades. Conversely, as more trees died, more space became available for recruits, seed came from older trees and ingrowth increased until mortality and ingrowth became more nearly equal.

Some species such as butternut, black cherry, aspen, gray birch, red cedar, and shadbush have either disappeared or nearly disappeared from the stand during the 30 years. If it should be desirable to maintain any of these species in a woodland, management that favors these, and even replanting, would be necessary.

Basal area increased from an average 70 sq. ft. per acre in 1927 to 100 in 1957. Basal area was greatest on the moist sites and least on the dry, but since the basal area increased more on the dry than on the moist sites, the difference has grown smaller. In 1927 oak comprised about half the basal area on dry but only one-seventh the basal area on the moist site; since oak basal area on both sites more than doubled while that of the other species scarcely changed in 30 years, the increase in basal area on dry was greater than on moist sites.

The number of trees per acre of the major species which were more than 5.5 inchs d.b.h. increased from 94 in 1927 to 156 in 1957. The number which were greater than 11.5 inches increased from 8 to 34. Meanwhile the number of trees less than 5.6 inches d.b.h. decreased from 979 per acre in 1927 to 359 in 1957. Thus, the woodlands have changed from thicket-like to more nearly forest-like.

The average height of the dominant and codominant trees in 1957 was 68 feet. When this height is compared to heights on a range of site qualities in Pennsylvania it indicates that our tracts are slightly better than medium.

Although the proportion of known sprouts did not change greatly in any major species among the dominant and codominant trees, it did decrease from 41 per cent in 1927 to 31 in 1957. The proportion of sprouts changed little among the intermediate and suppressed trees. Thus among the canopy but not among the understory trees, the proportion which occur singly increased.

Few intermediate or suppressed trees became dominant or codominant unless released. On hurricane-disturbed Turkey Hill, 44 intermediate or suppressed trees per acre became dominant or codominant, while only 8 did so on the three other tracts.

The larger and older trees were more defective than the smaller and younger trees, perhaps because the older trees have been exposed to causes of defects for longer. Nevertheless, it is a good sign that these smaller trees which may

eventually replace the older trees are less defective. The trees of known sprout origin were less defective than others. At least sprouts have no more visible defects than seedlings.

The steady increase in number of beech suggests that this presently unimportant species will become more important and thereby a factor in any trend toward less oak. This seems most likely on the drier sites where beech is most abundant and where oak now predominates.

Sugar maple also seems destined to become more important for its mortality rate is slight and its ingrowth rapid. Any increase in its importance would occur mainly on the moist and medium moist sites where it is most abundant.

In the woodlands an important feature of these three decades has been the growing predominance of oak: red, black, scarlet, and chestnut, particularly on the dry sites. White oak is still important, but it has actually decreased in importance during the last two decades.

Although oaks increased greatly in predominance on the tracts, their slight ingrowth suggests that the oaks may become somewhat less important should the stands be disturbed. Even on Turkey Hill where some larger trees of different species were felled in the 1938 hurricane ingrowth of oak increased only very slightly while that of other species increased greatly. Since ingrowth increased greatly among species other than oak during the three decades, a greater proportion of trees other than oak are available for replacement when some of the presently dominant trees die. Ingrowth of oak was slight on the dry sites, but nevertheless, better than on medium moist and miost sites. This trend toward less oak would be greater on moist sites.

Although fire caused great mortality on the burned area and delayed development of the stand by at least two decades, the species composition has not changed greatly. After the fire ingrowth was abundant and recovery has been rapid.

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED IN THIS BULLETIN

(Little, 1953)

Ash, white — Fraxinus americana
Ash, black — Fraxinus nigra
Aspen — Populus grandidentata
Basswood — Tilia americana
Beech — Fagus grandifolia
Birch, black — Betula lenta
yellow — Betula alleghaniensis
white — Betula papyrifera
gray — Betula populifolia
Blue beech — Carpinus caroliniana
Butternut — Juglans cinerea
Cedar, red — Juniperus virginiana
Cherry, black — Prunus serotina
Chestnut, American — Castanea dentata
Dogwood, flowering — Cornus florida
Elm, American — Ulmus americana
Hemlock — Tsuga canadensis
Hickory, bitternut — Carya cordiformis
Hickory, shagbark — Carya ovata
mockernut — Carya tomentosa
pignut — Carya glabra
Hophornbeam — Ostrya virginiana
Locust, black — Robinia pseudoacacia
Maple, sugar — Acer saccharum
red — Acer rubrum
Oak, white — Quercus alba
chestnut — Quercus prinus
red — Quercus rubra
scarlet — Quercus coccinea
black — Quercus velutina
Pine, white — Pinus strobus
Sassafras — Sassafras albidum
Shadbush — Amelanchier arborea
Tuliptree — Liriodendron tulipifera
Tupelo — Nyssa sylvatica
Witch-hazel — Hamamelis virginiana

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